NATO ADVANCED RESEARCH WORKSHOP

META'08

Metamaterials for Secure Information and Communication Technologies

7-10 May, 2008, Marrakesh - Morocco

Program and Abstract Book

Edited by

Saïd Zouhdi | LGEP-SUPELEC
Paris, France
May, 2008
meta.lgep.supelec.fr

Contents

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CONFERENCE VENUE

META'08 will be held on May 7-10, 2008, at the ATLAS ASNI Hotel, Marrakesh, Morocco.

SPECIAL EVENTS

Historical sightseeing tour of Marrakesh
On Thursday afternoon, May 8, 2008, join us for a guided tour of Marrakesh.

Conference Banquet
On Friday evening, May 9, 2008, the conference banquet with Fantasia Show is planned at "Chez Ali".

Excursion to Essaouira
On Saturday morning, May 10, 2008, join us for a full-day excursion to the charming city of Essaouira.

For META'08 participants and their guests, a limited number of tickets will be sold on-site on a first-come, first-served basis.

GUIDELINES FOR PRESENTERS

Oral Presentations

Each session room is equipped with a stationary computer connected to a LCD projector. Presenters must load their presentation files in advance onto the session computer. Technician personnel will be available to assist you.

Scheduled time slots for presentation are 20 minute each, including questions and discussions. Presenters are required to report to their session room and to their session Chair at least 10 minutes prior to the start of their session.

The session chair must be presented in the session room at least 15 minutes before the start of the session and must strictly observe the starting time and time limit of each paper and refrain from changing paper presentation sequence.

Poster Presentations

Presenters are requested to stand by their posters during their session. One panel will be available for each poster. Pins or thumbtacks are provided to mount your posters on the board. All presenters are required to mount their papers one hour before the session and remove them at the end of their sessions.

PROGRAM OVERVIEW

	Tue May 6	Wed May 7	Thu May 8	Fri May 9	Sat May 10
07:30					Excursion to Essaouira
08:00		Registration			
08:30		Opening ceremony	Session 9 / Session 10 / Session 11 / Session 12	Plenary session 3	
09:00		Plenary session1			
09:30					
10:00		Coffee break			
10:30		Plenary session 2	Coffee break & Poster II	Coffee break	
11:00				Plenary session 4	
11:30			Session 13 / Session 14 / Session 15 / Session 16		
12:00					
12:30		Lunch	Lunch		
13:00				Lunch	
13:30					
14:00		Session 1 / Session 2 / Session 3 / Session 4	Session 17 / Session 18 / Session 19 / Session 20	Session 21 / Session 22 / Session 23	
14:30					
15:00					
15:30			Visit of Marrakesh		
16:00		Coffee break & Poster I			
16:30				Coffee break & Poster III	
17:00		Session 5 / Session 6 / Session 7 / Session 8		Session 24 / Session 25 / Session 26	
17:30	Registration				
18:00					
18:30					
19:00					
20:00				Banquet	

TECHNICAL PROGRAM

Tuesday May 6, 2008

18:00-20:00 **The Registration Desk will be open at the Hall of the Hotel**

Wednesday May 7, 2008

08:00-08:30 **Registration**

08:30-09:00 **Opening ceremony**

Chaired by: Saïd Zouhdi

Plenary session 1

Chaired by: Costas Soukoulis

09:00-10:00

09:00 **Keynote talk**

Metamaterial Microwave Components Based on Dual Modes

A. Lai, Y. Kim, and T. Itoh

Abstract: This paper presents several examples of how mode concepts can be exploited in development of unique microwave components based on Composite Right/Left-Handed transmission line metamaterials.

09:30 **Keynote talk**

Cloaking by Reaction through Plasmonic Resonance

R. McPhedran

Abstract: There is much current interest in electromagnetic cloaking of objects, by exploiting structured materials. One approach cloaking by refraction, has been pioneered by J.B. Pendry and U. Leonhardt, and exploits metamaterials to create electromagnetic guiding around the region to be shielded. A second approach, cloaking by reaction, uses electromagnetic resonances in a coated cylinder, designed to have a resonant interaction between its coating and the surrounding material, to quench polarization responses in dipoles within an analytically-determined cloaking region surrounding the cylinder. We have extended the treatment to include interacting systems of polarizable dipoles or quadrupoles, and present animations illustrating that resonant cloaking still works for complicated assemblies of dipoles, or for higher order multipoles, and that the cloaking region does not depend on the details of the entity to be cloaked.

10:00-10:30 **Coffee break**

Plenary session 2

Chaired by: Vladimir Shalaev

10:30-12:30

10:30 **Keynote talk**

Review of possible approaches to electromagnetic cloaking of objects

S. Tretyakov

Abstract: In this lecture we will present an overview of various techniques allowing reducing “visibility” of objects probed by external electromagnetic radiation, and outline differences and similarities between stealth, invisibility, and cloaking. We will give a comparative historical overview of different approaches towards the goal of making objects “invisible” with respect to light or microwave radiation. Furthermore, the talk will present some latest results on electromagnetic cloaking achieved at our Department and outline perspectives for future research and applications.

11:00 **Keynote talk**

Mimicking quantum phenomena with classical metamaterials

N. Zheludev

Abstract: In this talk we aim to explore some parallels between the well established quantum effects and electromagnetic response of meta-materials. Keystone quantum phenomena like Electromagnetically Induced Transparency (EIT), Stimulated Emission, the Mossbauer Effect, the Meissner Effect and beta-decay are among those that have intriguingly close counterparts in electromagnetic meta-materials.

11:30 **Keynote talk**

Handedness in plasmonics: Electrical engineer's perspective

A. Sihvola

Abstract: This presentation focuses on the concept of handedness in complex media and metamaterials. Is it a property of the medium or the wave?

12:00 **Keynote talk**

Applications of Metamaterials in Antenna Designs: Concepts, Design and Optimization

Y. Rahmat-Samii

Abstract: Horizontal electric-type antennas that cannot radiate efficiently near a PEC ground plane due to the reverse image currents are capable to radiate efficiently near an EBG ground plane. It is revealed that the good return loss is contributed to the quadratic reflection phase of the EBG ground plane and the broadside radiation patterns result from the surface wave band gap. Various wire class antennas will be presented to demonstrate the utility of the concepts. Surface wave antennas with monopole type radiation patterns are also presented. It is noticed that when the vias in the mushroom-like EBG structures are removed, the reflection phase for the normal plane wave incidence remains the same whereas the surface wave band gap disappears. In this case, a well-matched short horizontal dipole or patch excites strong surface waves, and it works more like a transducer rather than a radiator. When the surface waves propagate

and radiate, a monopole type radiation pattern is generated. Thus, this antenna can be identified as a surface wave antenna, which is equivalent to a monopole but with a much less antenna height. Some recent trends will be highlighted.

12:30-14:00 Lunch

Session 1

Metamaterial Absorbers

Chaired by: Alain Priou

14:00-16:00

14:00 Scattering Cancellation Using Plasmonic Cloaks

A. Alù, and N. Engheta

Abstract: Use of metamaterials and artificial media for cloaking applications has been shown to potentially lead to exciting developments in the fields of electromagnetic, microwaves, and optics. Here we present our recent theoretical and numerical results for our cloaking technique that provides an overall invisibility effect by using plasmonic metamaterials.

14:20 Resonant microwave absorbers without a metallic backing based on metamaterials (Invited)

F. Bilotti and L. Vegni

Abstract: In this contribution, we present a review of our research on resonant metamaterial absorbers leaded by our group and conducted in cooperation with other groups. The common idea behind all the proposed layouts is the possibility to miniaturize the dimensions and to avoid the metallic backing of regular absorbers by using metamaterials. The principles of operation of each of the proposed setups are reviewed and some numerical results are presented to show the application capabilities of resonant microwave absorbers without a metallic backing.

14:40 Optimization of Radar Absorber Structures using Genetic Algorithms (Invited)

N. Lassouaoui, H. Hafdallah Ouslimani, A. Priou

Abstract: In this paper, a real-valued genetic algorithm (GA) is implemented to construct Radar Absorbing Materials RAM by searching the characteristics (thickness T, permittivity , permeability and conductivity σ) which ensure the minimization of the reflectivity for a given frequency f. We study the narrowband absorbers (Salisbury screen and circuit “Analog” RAM) and the broadband absorbers (Jaumann absorbers). Numerical results of the optimized structures are presented.

15:00 Blockage reduction of thick cylinders by shaping hard cross sections (Invited)

E. Rajo-Iglesias, J. M. Fernandez, and P.-S. Kildal

Abstract: In this work, the problem of reducing blockage caused by infinitely long cylinders is addressed by using oblong cross sectional shapes and hard surfaces. Firstly, the concept of equivalent blockage width for characterizing invisibility is reviewed. Then,

ideally hard cylinders with different cross sections are analyzed. It is shown that the electrical width of the cylinder defines which cross sectional shape performs better in these ideal cases. Finally, meta surfaces made of strips or mushrooms (patches with via holes) are presented as real coating solutions which reduce blockage simultaneously for TE and TM cases in cylinders with relatively large width.

15:20 Mutual Coupling Reduction Using A Thin Modified Electromagnetic Band Gap Substrate

F. Linot, X. Begaud, M. Soiron, C. Renard, B. Perpere

Abstract: A new solution to reduce the mutual coupling in arrays using a Loaded Electromagnetic Band Gap (LEBG) [1] reflector is presented. First, this reflector was developed to reduce the thickness of a very wideband antenna. We'll show that it can also be used to reduce the mutual coupling between dipoles.

15:40 On the impedance matching of left-handed materials to free-space

H. Boutayeb, K. Wu, and K. Mahdjoubi

Abstract: Using an original approach, this work shows that the impedance of left-handed materials (LHMs) is negative and a method to match left-handed materials to free space is proposed. A full-wave technique is used to validate our analysis and proposed scheme.

Session 2

Subwavelength Properties and Enhanced Transmission

Chaired by: Yiannis Vardaxoglou

14:00-16:00

14:00 Equivalent circuit model for extraordinary transmission

F. Mesa, F. Medina, and R. Marques

Abstract: Electromagnetic extraordinary transmission through periodic arrays of sub-wavelength holes has usually been approached by means of elaborated dynamical diffraction models. These models have been able to predict some unexpected features observed experimentally. However, the above approaches are basically numerical and do not provide much physical insight into the phenomena. This work presents an alternative standpoint for explaining extraordinary transmission that, via simple equivalent transmission-line circuit models, gives accurate numerical predictions in addition to provide a very efficient rationale for the observed phenomena.

14:20 Extraordinary Scattering Properties of Spheres with Radial Anisotropy (Invited)

C. W. Qiu S. Zouhdi, and L. W. Li

Abstract: Electromagnetic scattering of both coated and uncoated spheres with radial electric and magnetic anisotropy is studied. The role of anisotropy in plasmonic resonances has been investigated in uncoated anisotropic sphere. Also, it is shown that by the suitable adjustment of the radius ratio, one may make the anisotropic coated particle near transparent or invisible. In the quasistatic case, we take one step forward to

derive effective permittivity and permeability for the coated particle, and the near-zero scattering radius ratio can be well described within effective medium theory.

14:40 Properties of Sub-wavelength Resonances in Metamaterial Cylinders

S. Arslanagić, N. C. J. Clausen, R. R. Pedersen, and O. Breinbjerg

Abstract: The analytical solution for the canonical configuration with electric line source illumination of concentric metamaterial cylinders is employed to study the properties of the observed sub-wavelength resonances. The near- and far-field distributions, the frequency and geometry bandwidths, and the line source impedance are investigated for varying electromagnetic and geometrical parameters. The results of this study are of importance for metamaterial-based miniaturization of antennas.

15:00 Acoustic Metamaterials for Super-Resolution Ultrasound Imaging

S. Zhang and N. X. Fang

Abstract: We report the preliminary ultrasound imaging experiment of acoustic metamaterials composed of a planar network of subwavelength Helmholtz resonators. For the first time, we observed a tight focus using a thin slab lens of this acoustic metamaterial at 65 kilohertz. Because of the high resolution offered, this new class of metamaterials may find great potential application for underwater navigation or medical ultrasound screening.

15:20 Time-reversed waves, Metamaterials and super-resolution (Invited)

M. Fink, J. de Rosny, G. Lerosey , A. Tourin

Abstract: Time reversal focusing opens also completely new approaches to super-resolution. We will show that in random metamaterials, a time-reversed wave field interacts with the random medium to regenerate not only the propagating but also the evanescent waves required to refocus below the diffraction limit. Focal spots as small as $\lambda/30$ are demonstrated with microwaves. This results in a large increase of the information transfer rate by time reversal in such disordered media.

15:40 Experimental Verification of Supercoupling in Epsilon-Near-Zero Ultranarrow Channels and Bends

B. Edwards, A. Alù, M. Young, M. Silveirinha, and N. Engheta

Abstract: Epsilon-Near-Zero (ENZ) materials represent a special class of materials in which the permittivity is very small as compared to the permittivity of free space. As a direct result, the waves supported by such a medium possess an extremely large wavelength. Similarly, such a long wavelength emerges at the frequency at which the dominant mode of a waveguide enters cutoff. In this work we explore how far this analogy may be taken through a series of waveguide experiments aiming to verify the supercoupling phenomenon in ENZ ultranarrow channels.

Session 3

Chiral and bianisotropic metamaterials

Chaired by: Nikolay Zheludev

14:00-16:00

14:00 Optimal Shape of Spiral: Equality of Dielectric, Magnetic and Chiral Properties (Invited)

I. V. Semchenko, S. A. Khakhomov and A. L. Samofalov

Abstract: Spirals of the optimal form are investigated in a microwave range. The opportunity of transformation of linearly polarized electromagnetic wave of a microwave range in a wave with circular polarization using one-turn spirals having preliminary calculated optimal parameters is shown. It is shown, that investigated spirals show optimal properties at activation both electric, and a magnetic field, i.e. at any orientation of a plane of polarization of an incident wave.

14:20 TE- and TM-wave Decomposition of a Wave within Bianisotropic 1D Photonic Crystals

K. A. Vytovtov

Abstract: The simplest analytical method of investigating a wave transmission along an arbitrary direction within a one-dimensional bianisotropic photonic crystal (1D BPC) is developed. The method is based on the 2x2-translation matrix instead the well-know 4x4-matrices. The TE- and TM-waves decomposition of a total wave in BPC is presented for the first time in the accurate analytical form.

14:40 A geometric algebra approach to bianisotropy

S. A. Matos, J. R. Canto, C. R. Paiva, and A. M. Barbosa

Abstract: In this paper we show how a coordinate-free analysis of bianisotropy can be more easily handled through the new insight that only the unique approach to linear and multilinear functions provided by Clifford's geometric algebra can bring. We present three new contributions: i) we show how geometric algebra simplifies and gives a new geometric insight for general bianisotropic media; ii) we develop what we think is the most general approach for plane wave propagation in reciprocal bianisotropic media; iii) we present, as an example of application, new results for the specific case of pseudochiral omega media.

15:00 Chiral Swiss Rolls

M. C. K. Wiltshire

Abstract: We have constructed a variety of Chiral Swiss Rolls, a highly chiral radiofrequency metamaterial. We have measured the magnetic, dielectric and chiral responses of the individual rolls, which have a resonant frequency of ~ 83 MHz, and of both chiral and racemic bulk material.

15:20 Optical Magnetism in Chiral Meta-Materials

V. A. Fedotov, E. Plum, C. Soukoulis and N. I. Zheludev

Abstract: Optical magnetism, negative permeability and zero refractive index are demonstrated in 3D chiral meta-material that shows giant polarization rotation and circular dichroism.

15:40 Far- and Near-field Optical Studies of Chiral Plasmonic Metamaterials

M. R. Shcherbakov, P. P. Vabishchevich, B. B. Tsema, A. A. Zaitsev, A. S. Sigov, Y.-H. Fu, C.-M. Wang, D.-P. Tsai and A. A. Fedyanin

Abstract: Comprehensive far- and near-field optical study of different types of chiral plasmonic metamaterials is carried out. Giant optical activity of both linear and circular

dichroism is found for chirally nanoperforated silver film. The values of both types of dichroism are turned out to be tens of degrees for polarization plane rotation. Our results also emphasize the crucial role of surface plasmon polaritons in the mechanism of optical activity and circular dichroism of planar chiral metallic metamaterials.

Session 4

Cloaking and field manipulation

Chaired by: Ross McPhedran

14:00-16:00

14:00 Cloaking objects on a dielectric ground (Invited)

S. *He, P. Zhang, and Y. Jin*

Abstract: A scheme to cloak objects on a dielectric ground is proposed for the first time. The cloaking configuration consists of a semi-cylindrical cloaking cover and two vertical matching strips (of isotropic and homogeneous material) underneath. Coordinate transformation method is used to investigate the local reflection at the interface between the cloaking cover and a matching strip. By matching this local reflection coefficient to the air-ground reflection coefficient, we derive simple expressions for the material parameters of the matching strips. Numerical simulation and verification are given.

14:20 Full-field analysis on electromagnetic concentrator and cloak

X. Zhou and G. Hu

Abstract: Electromagnetic concentrator based on transformation method is analyzed by solving the boundary value problem. For a cylinder of radius R1 coated by the transformation metamaterial with the outer radius R3, a controlling parameter R2 is used to determine how many energy is concentrated within the cylinder. For any incident angles and any polarized waves, the concentration ratio (R2/R1)2 is theoretically derived by the full-field analysis. In the case of electric field parallel to the cylinder, it is found that the magnitude of transverse magnetic fields is also increased, while that of electric fields is unchanged. In addition, two interesting phenomena are found when this transformation model is extended.

14:40 Improvement of resolution of a scanning near-field optical microscope using efficient photon-plasmon coupling (Invited)

T. J. Antosiewicz and T. Szoplik

Abstract: Resolution of SNOMs depends mostly on the distance between a sample and the tip aperture and the aperture diameter. In tapered metal-coated aperture SNOM probes made of e.g. silica, illuminating light does not propagate beyond a cut-off diameter and only an evanescent field reaches the probe apex. We analyze the role of corrugations of the interface between the dielectric fiber core and metal coating in the enhancement of passing of energy. We calculate near-field light emitted from corrugated tips changing such groove parameters as profile, width, depth and their number.

15:00 Cylindrical Invisibility Cloak: Properties and Strategies for Practical Realization

M. Yan, W. Yan, L. Zhang, M. Qiu

Abstract: We compare simplified cylindrical cloaks derived from different simplification procedures. A superior simplified cloak, as compared to the previously reported version, is identified. We also show that the refraction of electromagnetic wave within cloak medium is affected heavily by the order of the spatial transformation function. Based on such effect we numerically demonstrate how to achieve near-perfect invisibility cloaks that have the same material parameters as ideal ones but with the inner singular boundary removed.

15:20 Impulse response of metallo-dielectric multilayer's operating in the canalization and broadband transparency regimes

R. Kotynski, J. Nowosielski, T. Stefaniuk, T. Szoplik and K. Panajotov

Abstract: We analyse the impulse response of layered metallo-dielectric stacks operating in the broadband tunnelling or canalization regimes. Our numerical simulations are based on the transfer matrix method and are compared to time domain propagation analysis. The impulse response largely depends on the existence of surface plasmon polariton modes for the structure. This effectively leads to trade-offs between resolution and aberrations. We discuss the possibility of using the transparent metallo-dielectric multilayer's with specific responses for mode coupling between photonic devices.

15:40 The dynamical process and the causality limitation of the dispersive cloak

X. Jiang

Abstract: For the first time, we simulate the dynamical process of the dispersive cloak (all real cloaking material must be dispersive) by the finite-difference time-domain (FDTD) method with special numerical techniques. The numerical experiments show several important properties of the dispersive-cloak dynamical process: unlike other systems, there is no oscillation in cloaking dynamical process; an "intensity front", which propagates in group velocity and sweeps through the cloak in the process, can surprisingly construct the "stable-cloaking rays" locally; the tangent group velocity, which is controlled by the dispersion, is the dominant element, and it determines the time length and total scattered field of dynamical process. Our further study of the dispersive cloak shows the deeper physical picture of the cloaking effect.

16:00-17:00 Coffee break & Poster Session I

Poster session I

Chaired by: Cheng-Wei Qiu

16:00-17:00

A1 Fabrication of a polymeric composite semiconductor metamaterial

A. A. Bayramov, N. A. Safarov and S. M. Bayramova

A2 Improvement of Shielding Effectiveness by different Materials

R. Oussaid and H. Saadi

A3 Spiral particle to design a compact resonator

S. Nemer, B. Sauviac, B. Bayard, C. Nader and J. Bechara

A4 **Design of polygonal or elliptical invisibility cloak**

P.-H .Tichit, B. Kante and A. de Lustrac

A5 **Stop band filter in GSM bands by using a deformed one dimensional quasi periodic crystal photonic**

Y. Trabelsi, M. Kanzari, and B. Rezig

A6 **A Summation Rule Experimental Results for Metamaterials**

C. Larsson, C. Sohl, M. Gustafsson, and G. Kristensson

A7 **Characterization of a short wire dipole enclosed by an ENG spherical shell using the volume-surface integral equation**

O. S. Kim and O. Breinbjerg

A8 **Simulation of Ferrite Media Using The Scattering TLM-Matrix**

A. Zugari, E. Hamham, M. I. Yaich and M. Khalladi

A9 **Application of Metamaterial Resonators in the design of Ultra Compact Band Pass Filters**

M. Gil, J. Bonache, F. Martín

A10 **Engineering left-handed multi-layered metamaterials under normal to plane propagation**

S. N. Burokur, B. Kanté, and A. de Lustrac

A11 **Modelisation Of Metamaterials For Active Radome**

G. Lunet, V. Vigneras, H. Kassem, L. Oyhenart

A12 **Photonic Crystal Wavelength Demultiplexer based on Self-Collimation Effect**

S.-G. Lee, J.-E. Kim, and H. Y. Park

A13 **Perfect invisibility cloaks constructed by arbitrary coordinate transformations**

W. Yan, M. Yan, Z. Ruan, and M. Qiu

A14 **Self-organized TiO2-MnTiO3 eutectic with 3D fishnet-like microstructure**

K. Kolodziejak, D. A. Pawlak, M. Kafesaki, I. Tsiapa, N. Katsarakis, K. Rozniatowski

A15 **A General Synthesis Method For Cylindrical Phased Antenna Arrays**

N. Fadlallah, H. Rammmal, Olleik, M. Rammal

A16 **Light scattering by a disperse layer with spatial correlation of particles**

V. A. Loiko, V. V. Berdnik

A17 **Effects of Ion Chemistry and Mass on the Electrical Properties of Ion Implanted Pyrolysis Polyacrylonitrile**

S. Jodeh

A18 **Spectroscopic Diagnosis in Electronic Temperature of Plasmas Purely Photoionized**

A. K. Ferouani, M. K. Inal

Session 5

EBG and photonic crystals I

Chaired by: Alexey Vinogradov

17:00-18:20

17:00 Polarization conversion assisted by surface waves on photonic crystal

M. Laroche, F. Marquier, C. Vandenbem and J.-J. Greffet

Abstract: Using photonic crystals to mimic plasmonics is very promising since the dispersion relation of surface waves can be tailored by the lattice parameters. In this work, we demonstrate, for the first time, that efficient polarization conversion can occur on photonic crystals. The key role of leaky surface modes supported by the photonic crystal slab will be emphasized.

17:20 An Optimised Planar EBG Unit Cell for MHz to GHz Range Applications

R. H. Geschke

Abstract: A novel uniplanar unit cell design is introduced. An optimised element for low frequencies that produces a propagation stopband in the low MHz range up to 1 GHz is presented. This is extended to a wider bandwidth, extending into the GHz range, by employing a combination topology of cells with varying geometrical parameters. Parameter studies of the key geometrical parameters are presented to determine the optimal design values for the unit cell, as determined by the required stopband frequency range.

17:40 One dimensional photonic crystal with semiconducting constituents: the role of the absorption mechanisms

F. Ramos-Mendieta and J. Manzanares-Martinez

Abstract: We have calculated the photonic band structure (PBS) and the optical properties of two periodic layered systems, air/LiT aO2 and air/InSb. In our calculations the dielectric constant of the semiconductors takes into account the phononic contributions. Intrinsic electronand hole densities are also considered for the InSb. The PBS presents metallic behavior at two frequency regions, just above the transverse phononic frequency and below the effective plasma frequency. Further, the absorption mechanisms give rise to inflexion points in some bands – the curve of dispersion returns without reaching the Brillouin zone limit.

18:00 Negative Refraction in One-Dimensional Photonic Crystals

R. Srivastava, K. B. Thapa, S. Pati and S. P. Ojha

Abstract: Recently it has been shown that photonic crystals (PCs) may exhibit negative refraction although they have a periodically modulated positive permittivity å and permeability µ. We have theoretically studied the negative refraction in one-dimensional (1D) photonic crystals (PCs) consisting dielectric ZnSe with air. By using transfer matrix method and block theorem we have studied the photonic band structure and group velocity and with the help of group velocity we have obtained the frequency bands of negative refraction.

Session 6

Homogenization of metamaterials I

Chaired by: Ari Sihvola

17:00-18:40

17:00 Metamaterials based on high refractive index rods

K. Vynck, D. Felbacq, E. Centeno, A. I. Căbuz, and D. Cassagne

Abstract: Recent studies report the possibility of designing metamaterials with high-refractive index rods. In this theoretical work, we discuss the physical origin of negative permittivity and permeability in dielectric rods structures. Based on a rigorous theory and reliable calculations, we show how their macroscopic properties are related to the microscopic properties of the dielectric rods and investigate their scaling properties with a renormalization-based scheme.

17:20 Effective Coefficients for Metamaterials via Frequency-Dependent Homogenization (Invited)

A. Bossavit

Abstract: A method to compute effective coefficients by solving a small number of boundary value problems on the periodicity cell. Justification (by a convergence result) and examples, showing that effective coefficients, which depend on angular frequency ω, behave as expected: Real part negative in some definite frequency window, resonance.

17:40 Analytical Modeling of Surface Waves on High Impedance Surfaces

A. B. Yakovlev, C. R. Simovski, S. A. Tretyakov, O. Luukkonen, G. W. Hanson, S. Paulotto, and P. Baccarelli

Abstract: In this paper, analytical modeling of natural modes is proposed for the rapid and accurate analysis of various high impedance surfaces (HIS) composed of dense grids of FSS elements printed on an electrically thin grounded dielectric slab. The model is based on the homogenization of grid impedance in terms of effective inductance and capacitance, which are obtained from the full-wave solution of a plane-wave scattering problem in the quasi-static limit via the averaged impedance boundary condition.

18:00 Topology Optimization in Metamaterial Design

A. R. Diaz and O. Sigmund

Abstract: A strategy to design metamaterials based on topology optimization is introduced. The approach is based on proven methodologies used in material design in other engineering contexts (elasticity, photonics) and seeks to produce metamaterials with novel micro-geometries that result in single and double negative effective properties.

18:20 Modeling of light propagation in nanorod arrays using nonlocal homogenization theory and exact electromagnetic solution

D. V. Nesterenko, and V. V. Kotlyar

Abstract: The propagation of transverse magnetic (TM) and transverse electric (TE) polarized light in periodic array of metallic nanorods of various radii in dielectric slabs was studied. The transmission and reflection of structure with nanorod arrays calculated by hybrid finite element method and boundary element method approach were compared

with results of modeling the slab with effective permittivity estimated by nonlocal homogenization theory (NHT).

Session 7

Metamaterials for Aerospace

Chaired by: André de Lustrac

17:00-18:40

17:00 Metamaterials for Aerospace Applications (Invited)

Invited M. Tanielian, C. Parazzoli, R. Greegor, J. Nielsen, T. Lam, R. Ziolkowski, D. Smith and N. Engheta

Abstract: The advent of metamaterials has opened up the possibility for new electromagnetic structures and configurations having a negative effective dielectric permittivity and/or magnetic permeability.

17:20 Design of a New Type of Metamaterial Radome for Low Frequencies

M. Latrach, H. Rmili, Ch. Sabatier, E. Seguenot and S. Toutain

Abstract: A new type of radome was designed around 2 GHz, comprising alternately layers with negative permeability and positive index of refraction materials. The negative permeability, obtained by the SRRs network and the thickness of the radome are optimized so that the radiated electromagnetic waves generated by the antenna are passing through without any reflection. A compact electrical size of the SRR structure (~λ/20) was obtained by optimizing the geometrical and electrical parameters like increasing the coupling between the resonators. The effect of the radome on the antenna characteristics is evaluated by simulation and measurements with a good agreement. Enhancement of the gain, the directivity and the frequency bandwidth is observed.

17:40 Dual Band ChessBoard Structure to Reduce RCS

J. C. Iriarte, M. Paquay, I. Ederra, R. Gonzalo, P. de Maagt

Abstract: A planar chessboard structure with RCS value reduction in two frequency bands is presented in this paper. Reflected power in specular direction is reduced in two frequency ranges by using two different AMC structures. A 180º degrees difference between reflected waves in both AMCs is achieved at both frequency ranges. Half of the cells of the chessboard have been filled with Sievenpiper mushrooms while the other half have been filled by an array of spiral AMCs. Simulation results have been obtained using Ansoft HFSS.

18:00 Input Impedance of EBG Antennas versus Source Position (Invited)

T. H. Vu, K. Mahdjoubi, S. Collardey, A.C. Tarot

Abstract: A simple and efficient electromagnetic model has been recently proposed to tackle the difficult subject of the input impedance of planar metamaterial antennas (EBG, FP, AMC backed, etc.). In this paper, we apply the model to study the behaviour of the input impedance of the exciting source as a function of its position in an FP (Fabry-Perot Cavity) or EBG (Electromagnetic Band Gap) structure for two types of the reflecting plane, namely PEC and PMC. AMC reflectors will be studied in a later work.

18:20 Metamaterial-based Cavity for Ultra-Compact and Highly Directive Phased Array Antennas (Invited)

A. Ourir, A. de Lustrac

Abstract: In this paper the design of a metamaterial-based cavity is presented to realize a low secondary lobes level and highly directive phased array antennas. The radiation patterns of several phased arrays are compared to those of their respective metamaterial-based cavity antennas. The latter structures are low profile, has low secondary lobes level, provide higher gain and directivity and achieve a better beam steering.

Session 8

Metamaterials Design and Characterization I

Chaired by: Ricardo Marques

17:00-18:40

17:00 Split Ring Resonator Metamaterial Structures on Semiconductor Substrates (Invited)

N. P. Johnson, B. Lahiri, A. Z. Khokhar, R. M. De La Rue and S. G. McMeekin

Abstract: The use of active substrates gives the potential for control of the resonant properties of split-ring resonator (SRR) structures by means of active changes in the carrier concentration obtained using either electrical injection or photo-excitation. We have measured the properties of a range of SRR array structures with different size parameters and geometries on both silicon and gallium arsenide substrates. We have also used several different metallisation schemes in the realisation of these SRR arrays.

17:20 Experimental and theoretical characterization of optical metamaterials

B. Kante, F. Gadot, S. N. Burokur, A. de Lustrac

Abstract: In this paper, we present the design, simulation, fabrication and measurement of different metamaterials working under normal to plane propagation. The different metamaterials are derived from a combination of split ring resonators (SRR) and nano-continuous wires. A plasmonic interpretation of the resonances leads to a better understanding of their origin. An original method is also proposed and achieved experimentally to measure the phase information in the infrared.

17:40 Design of Miniaturized Bandpass Waveguide Filter Utilizing Complementary Split Ring Resonators (CSRR)

H. Bahrami, M. Hakkak and A. Pirhadi

Spilt Ring Resonators (SRRs) and Complementary Split Ring Resonators (CSRRs) when excited by suitable electromagnetic fields have resonance behavior. In this paper, CSRRs are used to design a bandpass waveguide filter in the X-band.

18:00 Characterization of millimeter-wave metamaterials

K. B. Alici, and E. Ozbay

Abstract: In the present work, we demonstrate two different double negative metamaterial media, which are fabricated by using simple printed circuit board techniques, operating at the millimeter-wave region. First double negative medium was composed of split ring resonators and wires and the other medium is known as fishnet structure. The transmission based experimental characterization was supported by numerical simulations and standard retrieval analysis. Both metamaterials operate at around 100 GHz. The bandwidth and loss properties are studied by increasing the number of metamaterial layers at the propagation direction. We conclude split ring resonator based medium has larger operation bandwidth but it is relatively hard to compose.

18:20 A new left-handed metamaterial structure design: Theory and Simulation

R. Rian and M. Essaaidi

Abstract: In this paper, we present a new left-handed (LHM) medium or metamaterial structure, which has a broadband negative refraction index. We also show that there is a frequency band where the permittivity and permeability are simultaneously negative. The retrieval technique is provided for the analysis of this new metamaterial, We analyze the reflection and transmission coefficients calculated from transfer matrix simulations on finite lengths of electromagnetic metamaterials, to determine the effective permittivity (ε) and permeability (μ). We perform this analysis on structures composed of periodic arrangements of wires and split ring resonators (SRRs).

Thursday May 8, 2008

Session 9

Wideband Applications of Metamaterials I

Chaired by: Xavier Bégaud

08:30-10:30

08:30 Bandwidth limitations on passive metamaterial applications (Invited)

C. R. Brewitt-Taylor

Abstract: Metamaterial electromagnetic properties are a key to improved device performance and novel devices. However, not all desired properties are physically realisable. This paper discusses the limitations on any causal and passive material, material dispersion, and the resulting limitations applying to absorbers, magnetic conductor surfaces, small antennas, subwavelength imaging, and cloaking. Previous limitations on magnetic conductor surfaces are extended to oblique incidence.

08:50 On the Fundamental Limitations of Artificial Magnetic Material (Invited)

A. Kabiri, L. Yousefi and O. M. Ramahi

Abstract: In order to study the functionality of physical and geometrical properties of inclusions in engineered magnetic materials, a novel model is developed which integrates all parameters in two geometrical and physical indices. To generalize this framework for any type of applications, all frequencies are normalized to the operational

frequency. Based on this model, a geometry invariant fundamental constraint is derived. This constraint provides the operational bandwidth restriction based on the amount of permissible variation of the effective.

09:10 Frequency Selective Structures for Wideband Applications (Invited)

J-B. Robertson, B. Sanz-Izquierdo, J.C. Batchelor and E. A. Parker

Abstract: With current interest in mobile communications, Frequency Selective Surfaces (FSS) need to be applied over wider fractional bandwidths than is customary at many microwave applications. The regions of interest can extend from about 300MHz to 3GHz and beyond. This is a very wide spectrum. One point of interest is to incorporate FSS into the built environment, which may require signal access at the emergency service bands, such as at 400MHz in the UK, and admitting other bands perhaps, whilst screening internal services from external interference to minimise the outage probabilities. The paper includes a discussion of densely packed structures and highly convoluted geometries.

09:30 Ultra Wide Band Pass Filters based on Metamaterial Transmission Line

M. Gil, J. Bonache, F. Martín

Abstract: In this paper, the authors state the application possibilities of resonant-type metamaterial transmission lines based on Complementary Split Ring Resonators (CSRRs) in the design of ultra wide band pass filters (UWBPF) with compact dimensions and good performances.

09:50 Physical analysis of wideband antennas on artificial magnetic ground plane (Invited)

R. Mateos and C. Craeye

Abstract: Artificial magnetic ground planes enable the placement of horizontal dipole-type antennas close to the ground plane. This works thanks to a reflection coefficient with a phase close to zero, with respect to a plane wave incident from broadside. Unfortunately, this behaviour is valid only over a small frequency band and the slope of the phase shift is opposite to the one favorable to wideband behaviour. The latter would require a phase increasing with frequency, which is not permitted by the Foster theorem.

10:10 Bandwidth Enlargement of EBG Antennas by a Combined PRS

T.H. Vu, A.C. Tarot, S. Collardey, K. Mahdjoubi

Abstract: An analytical method has been recently proposed to enlarge the bandwidth of FP and EBG antennas. Based on the application of the plane wave theory, the bandwidth improvement concerns the ideal plane wave excitation. The objective of this presentation is to verify the validity of the method for real case sources such as dipole antennas.

Session 10

Recent advances in metamaterial transmission lines and applications I

Chaired by: Ferran Martin

08:30-10:30

08:30 Selected Applications of 1D Metamaterial Transmission Lines for RF Components and Sensors

M. Schüßler, C. Damm, A. Penirschke, R. Jacoby

Abstract: The paper describes selected applications of 1d metamaterial transmission lines. Starting from the classical planar metamaterial transmission line approach improved properties or new device functionalities are obtained by integration of tunable elements or geometrical modifications of the structures. This is illustrated by means of examples for a tunable artificial line, a delay line, a compact microstrip patch like antenna and a flow sensor.

08:50 Bloch Wave Analysis for Multimode Periodic Structures: Applications to Transmission Line Metamaterials

F. Bongard, J. Perruisseau-Carrier, and J. R. Mosig

Abstract: An extension of the Bloch wave analysis for periodic structures which allows taking into account the effect of several modes of the host guiding structure will be presented. Applications of this modeling technique will be illustrated through some examples of transmission line based metamaterials.

09:10 Microwave devices with improved functionality using metamaterial transmission lines (Invited)

I. B. Vendik and D. V. Kholodnyak

Abstract: The general approach to a design of miniature microwave devices based on metamaterial transmission lines with positive and negative dispersion is considered. Using combination of these lines exhibiting different dispersion characteristics gives additional degrees of freedom for improving microwave device performance and enlarging functionality. The following passive devices are under consideration: miniature broadband microwave directional couplers, dual-band and multi-band resonators and filters. The potential benefit of application of these microwave devices is discussed.

09:30 Dispersion Engineering in Resonant Type Metamaterial Transmission Lines and Applications (Invited)

G. Sisó, M. Gil, J. Bonache and F. Martín

Abstract: In this work, it is demonstrated that metamaterial transmission lines based on complementary split ring resonators (CSRRs) are useful for applications requiring dispersion engineering, such us broadband or multi-band components. These artificial lines, consisting on a host line and loading elements (CSRRs and series gaps), exhibit a major number of degrees of freedom as compared to conventional lines, this being the relevant characteristic for tailoring their dispersion diagram. The theoretical foundations, as well as prototype device examples, illustrative of the achievable results, are provided.

09:50 Composite Right/Left-Handed Transmission Lines in Distributed Amplification and Mixing

C. Camacho-Peñalosa, T.M. Martín-Guerrero, and J. Mata-Contreras

Abstract: Composite Right/Left-Handed Transmission Lines (CRLH TLs), introduced in 2002 [1, 2], are artificial transmission lines which mimic the behaviour of transmission lines filled with double negative (DNG: simultaneous negative permittivity and negative permeability) homogeneous, linear and isotropic media. Their most interesting

characteristic, when compared with 'conventional' Right-Handed (RH) TLs, is the much richer behaviour exhibited by their propagation constant.

10:10 Tunable metamaterial transmission lines based on complementary split ring resonators (CSRRs): two approaches

A. Vélez, J. Bonache, X. Rottenberg, I Gil, W. de Raedt and F. Martín

Abstract: Two different approaches are considered for the synthesis of metamaterial transmission lines based on complementary split ring resonators (CSRR) with tuning capability: the varactor loaded CSRR (VLCSRR), and the MEMS-loaded CSRR. In both cases, the electrical characteristics of the resonant particles can be electronically controlled, and tuning is achieved. The design strategies and applications are discussed to the light of fabricated prototype.

Session 11

Electromagnetic metamaterials and structures with abnormal properties I

Chaired by: Sailing He

08:30-10:30

08:30 *Improving Optical Cloaking by Designing the Coordinate Transformation Function*

Y. Feng, X. Xu, T. Jiang

Abstract: By properly designing the coordinate transformation function, we show that the performance of a nonmagnetic cloak could be improved with minimized scattering fields, and due to the monotonic transformation function, the cloak has no restriction on the size of the cloak shell.

08:50 Electromagnetic mode trapping for giant optical field enhancement

T. V. Teperik, R. Sainidou, F. J. Garcia de Abajo

Abstract: We propose a purely dielectric nanostructure that allows producing arbitrary large resonant optical field enhancement mediated by trapped modes. We demonstrate that a simple square periodic array of small dielectrical particles can trap electromagnetic modes with different electromagnetic symmetries. While a single dielectric particle of size much less then the light wavelength does not exhibit resonant electromagnetic response, the noted square array can effectively trap electromagnetic modes due to dipole-dipole interaction induced by both electric and magnetic response of the single particles.

09:10 Anisotropic permittivity with a zero component for spatial filtering

Y. Jin, S. L. He

Abstract: A slab of specially-designed anisotropic permittivity with a zero component can be used as a spatial filter for normal or oblique incidence. The maximum transmissivity is high and the transmissivity peak is narrow. A periodic multilayered structure consisting of isotropic layers is suggested to realize such anisotropic permittivity.

09:30 Negative refraction in chiral composites

W. T. Dong and L. Gao

Abstract: Based on the extended Maxwell-Garnett approximation, we realize the negative refraction in chiral composites in which electrically small isotropic chiral inclusions are randomly embedded in an isotropic achiral host medium. Numerical results show that there exists negative refraction in high (low) frequency region for right (left)-circular polarized wave, and the region is widened for large volume filling fraction and for small damping factor. Careful investigation indicates that the negative refraction results from the large effective chirality parameter obtained in the chiral composites.

09:50 Transformation and moving media as applications of an equivalence principle for electromagnetics

M. A. Ribeiro and C. R. Paiva

Abstract: By using geometric algebra, a new vacuum form reduction enables an important simplification of our spacetime constitutive relation. In this work we present several applications form the perspective of a unifying concept provided by this equivalence principle for electromagnetics and using the mathematical language of geometric algebra: (i) invisibility cloaks, as applications of transformation media; (ii) moving media, as the materials interpretation of a geometric transformation between two frames in relative motion; (iii) a generalized version of Snell's law at the interface between two transformation media in relative motion.

10:10 Represent Dispersive and Lossy Negative Index Metamaterials in Material Phase Space (μ'/μ",ε'/ε")

R.-X. Wu and A.-M. Jiang

Abstract: Real dispersive metamaterials have negative index of refraction when the real parts of the complex permittivity ε=ε'-jε" and the complex permeability μ=μ'-jμ" are double negative or even single negative. To represent the whole negative index regime, a materials phase space (μ'/μ", ε'/ε") is introduced and conditions for negative index derived. Under the different conditions the loss of the negative index metamaterials is discussed. And a numerical example is given.

Session 12

Plasmonics I

Chaired by: Javier Garcia de Abajo

08:30-10:30

08:30 Metamaterial combining localized and extended surface plasmons: application to hybrid plasmonic crystals

J. Cesario, M. U. Gonzalez, J. C. Weeber, S. Enoch, and R. Quidant

Abstract: We report on the observation of a full non-Bloch plasmonic bandgap emerging from the electromagnetic coupling between collective localized surface plasmon resonance sustained by a metallic nanoparticles array and a surface plasmon supported at metal dielectric interface. By combining simulations based on the Fourier modal Method (FMM) with direct observations of the surface plasmon waves via Leakage Radiation Microscopy (LRM) we study the influence of the structural parameters on the position and the bandwidth of the bandgap obtained. A physical explanation of the formation of the bandgap is proposed.

08:50 Plasmonic Components for Nano- and Meta-Photonics (Invited)

A. Boltasseva

Abstract: Different fabrication approaches for realization of advanced plasmonic components (both passive and active) are reported including manufacturing of nanophotonic waveguides, plasmonic nanoantennae and metamaterials.

09:10 Surface waves generated by nano-objects (Invited)

P. Lalanne, H. Liu

Abstract: We describe the nature of the surface waves that contribute to the interaction between nano-objects on a metal surface. We show that the interaction is mediated by two-different fields, the surface plasmon and a quasi-cylindrical wave creeping at the surface. Both waves are important to understand subwavelength interaction processes.

09:30 Large Area Plasmonics Structures recorded by Holographic Lithography

J. W. Menezes, E. S. Braga, and L. Cescato

Abstract: In this work, we recorded large area plasmonics structures using holographic lithography followed by a lift-off process. The zero-order transmission spectra of the samples were measured using UV-Vis spectrophotometer. The results show the typical surface plasmon resonances (SPR) in the visible spectrum.

09:50 Numerical investigation of resonant surface modes at the interfaces of composite DNG/SNG materials

D. L. Sounas, N. V. Kantartzis, and T. D. Tsiboukis

Abstract: An extensive finite difference time domain (FDTD) analysis of the surface modes excited at the boundaries between different composite metamaterials, consisting of thin wires and split ring resonators (SRRs), is conducted in this paper. The numerical dispersion relation, field distribution and energy flow are compared to the analytical ones, obtained via the effective medium model.

10:10 Plasmon guided modes in nanoparticle metamaterials

R. Sainidou and F. J. García de Abajo

Abstract: Surface modes in nanostructured metallic metamaterial films are reported showing larger confinement than plasmons in metallic waveguides of similar dimensions, but in contrast to plasmons, the new modes have TE polarization. The metamaterial, formed by planar arrays of nearly-touching metallic nanoparticles, behaves as a high-index dielectric for the noted polarization, thus yielding well confined guided modes. Our results for silver particles in silica support a new paradigm for TE surface-wave guiding in unconnected nanostructured metallic systems complementary to TM plasmon waves in continuous metal surfaces.

10:30-11:30 Coffee break & Poster Session II

Poster session II

Chaired by: Ouail Ouchetto

10:30-11:30

B1 **Applications of Metamaterials in Optical Waveguide Isolator**

R. J. El-Khozondar, H. J. El-Khozondar and M. M. Shabat

B2 **MEMS Based Reconfigurable CRLH Transmission Line**

G. Monti, R. De Paolis, L. Tarricone

B3 **CRLH Ferrite Quarter Wavelength Impedance Transformer with Significantly Reduced Size**

M. A. Abdalla, and Z. Hu

B4 **The new nonlinear phenomena in the photonic crystals around the self-collimation frequency**

X. Jiang

B5 **Photonic Crystal Slab Filters in the Infrared Range**

S. Soon Oh, and C.-Gi Choi

B6 **Application of reconfigurable bi-layered metamaterials in a wideband cavity antenna**

S. N. Burokur, A. Ourir, A. de Lustrac, P. Ratajczak and J.-P. Daniel

B7 **Efficient Beaming in the Emission of Self-Collimated Light in Photonic Crystals**

J.-M. Park, J.-E. Kim, and H. Y. Park

B8 **Conformable Radomes based on bil-layered Electromagnetic Band Gap Materials**

S. Haché, S. N. Burokur, F. Gadot, P. Cailleu, G.-P. Piau, A. de Lustrac

B9 **An Effective Lumped Impedance Surface for HIS**

Y. Zhu, O. Ouchetto, C.-W. Qiu, L. Santandrea and S. Zouhdi

B10 **Combining frequency selective surfaces for broadband resonators design**

L. Moustafa and B. Jecko

B11 **A geometric algebra approach to media with both general electric and magnetic anisotropy**

J. R. Canto, S. A. Matos, C. R. Paiva, and A. M. Barbosa

B12 **Strong Electric Field Effects on SPP Propagation in Nanostructures**

A. Al-Jabr and M. A. Alsunaidi

B13 **Accurate implementation of the Finite Difference Time Domain Method to the calculation of the evanescent fields in a dispersive metamaterial**

J. Manzanares-Martinez, and J. Gaspar-Armenta

B14 **Characterisation of left-handed materials with quasi-optical method in millimetre wave band**

A. Elhawil, D. Zhang, S. Islam, A. Franchois, R. Vounckx, J. Stien

B15 **Sidelobe Reduction in Array-Pattern Synthesis Using Circular Antenna Arrays**

N. Fadlallah, R. Ghayoula, A. Gharsallah, , M. Rammal

B16 **Elaboration and Characterisation of New Hybrid Resulting of Mixture PANI/Nb3Sn**

O. Boubekka, Z. Ouili, H. Alliouche

B17 **Error Reconciliation modeling in quantum information protocol with One-Time Pad cipher**

S. Aris, N. Merabtine, and M. Benslama

B18 **Initial Stage of Nanocrystalline Mechanically Alloyed Fe 50 Ni 25 Al**

A. Otmani, A. Djekoun, B. Bouzabata, N. Randrianantoandro and J. M. Greneche

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Session 13

Wideband Applications of Metamaterials II

Chaired by: Xavier Bégaud

11:30-12:10

11:30 **Loaded Electromagnetic Band Gap Reflector With a Thin Film Resistor (Invited)**

M. Grelier, X. Begaud, and L. Schreider

Abstract: We propose to improve a reflector based on a novel electromagnetic band-gap with loads (LEBG) by using sheet resistance instead of chip resistor. To validate the concept, an Archimedean spiral has been backed to this new reflector. Two prototype antennas present a very thin thickness, λ/100 and λ/150 at the lowest operating frequency, a good impedance matching and Right Hand Circularly Polarized patterns over a 9:1 bandwidth.

11:50 **On The Study of Left Handed CPW Devices on Ferrite Substrate (Invited)**

M. A. Abdalla, and Z. Hu

Abstract: In this paper, we present a set of novel LH microwave circuits implemented on ferrite substrates. The reported circuits demonstrate the advantages of compact size, tunable, and non reciprocal performance.

Session 14

Recent advances in metamaterial transmission lines and applications II

Chaired by: Ferran Martin

11:30-12:30

11:30 **Micromachined and MEMS-reconfigurable Ku-band TL-based Metamaterials**

J. Perruisseau-Carrier, A. K. Skrivervik, and J. R. Mosig

Abstract: In this presentation, we will review recent activities on the design of composite right/left handed transmission lines (CRLH-TLs) based on micromachining fabrication techniques, as well as their reconfiguration by means of MEMS.

11:50 Metamaterial approach for ultra-high frequency filtering

A. Lucas, J. Carbonell, V. E. Boria, M. Chaubet and D. Lippens

Abstract: We report on the design, the fabrication and the RF assessment of an ultra narrow band pass filter operating at G band at millimeter waves. We target a central frequency of 150 GHz and a bandwidth of 2 GHz with a steep rejection (-30 dB @ 1.5 GHz) so that a metamaterial technology was chosen to fit the expected performance. Split ring resonator (SRR) and complementary C-SRR are studied and compared on a scale compliant with MMIC's technology.

12:10 On the Realization of Left-handed Metamaterials for RF and Microwave Monolithic Integrated Circuit Applications

Z. Hu

Abstract: In the past few years, there has been a great interest in using metamaterials in RF/microwave circuit applications. The unique properties of LH metamaterials make them very attractive to be used in RF and microwave planar circuit applications. Recently, MMIC approach on realizing miniaturized left-handed circuits has been proposed. In this paper a set of novel miniaturized left-handed RF/MMIC band pass filters, high pass filters, transformer and zero phase shifter are reported. These circuits are constructed using nearly pure left-handed transmission lines and novel dual-composite right/left handed transmission lines and realized by GaAs MMIC technology. The circuits show excellent performance and significantly reduced size. Newly developed multilayer MMIC left-handed basic block components will also be presented.

Session 15

Electromagnetic metamaterials and structures with abnormal properties II

Chaired by: Sailing He

11:30-12:30

11:30 Novel Polarization Beam Splitter using 1D Periodic Structure

Y. Zhang, Y. R. Jiang, S. He and W. Xue

Abstract: We studied a special multi-layered dielectric periodic structure and found it has a very different spatial dispersion for the two different polarizations: at some frequencies the equal-frequency contours are flat for TE but still curve for TM polarization. Based on this property we propose two new kinds of polarization beam splitter, and one of them even has a broad-angle property (from 0° to 70°).

11:50 Manipulating electromagnetic-wave polarizations and transmissions by meta-materials: polarization conversion and transparency

L. Zhou

Abstract: Meta-materials are a class of artificial materials constituted by subwavelength microstructures with tunable electromagnetic (EM) properties, and thus possess many extraordinary properties which do not exist in nature. In this talk, we show that employing specifically designed meta-materials, one can freely manipulate many fundamental properties of EM waves, including the polarization states of EM waves and the transmission properties of EM waves through a particular medium.

12:10 Compact Broader-dual-band Rat-Race Coupler Based on a Composite Right/Left Handed Transmission Line

X. Hu and S. He

Abstract: In this paper, the general model for dual band rat-race couplers by applying the odd-even mode analysis approach is demonstrated, and the requirements for the impedance and electrical length of branches are given. Choosing appropriate ratio of the impedances of the branch and the port in the configuration according two different centre frequencies, we can obtain arbitrary dual-band rat-race coupler.

Session 16

Plasmonics II

Chaired by: Tomasz Szoplik

11:30-12:30

11:30 Non-local effects in strongly-interacting plasmons (Invited)

F. Javier García de Abajo

Abstract: Non-local effects in the optical response of noble metals are shown to produce significant blueshift and near-field quenching of plasmons in nanoparticle dimers, nanoshells, and thin metal waveguides. Compared with a local description relying on the use of frequency-dependent dielectric functions, we predict resonance shifts as large as 10% and field-intensity reduction of an order of magnitude at inter-particle distances or metal thicknesses below 2 Å. A roadmap is presented to design plasmon resonances in nanometer metallic elements with application to optical antennas and improved photovoltaic, light-emitting, and sensing devices.

11:50 Migrating Magnetoplasmons in the Magnetised Layered Semiconductor-Dielectric Structures (Invited)

A. G. Schuchinsky, X. Yan

Abstract: The eigenmodes in the layered structures containing magnetically biased semiconductor films have revealed unusual features of migrating between the frequency bands and layer interfaces. It is shown that at certain combinations of the structure parameters, the magnetoplasmons localised at opposite interfaces of the guiding layer can interchange their positions while preserving the parity of their field distributions. The intriguing properties of the magnetoplasmon transformations are illustrated by the respective field and power flow distributions.

12:10 Plasmon guided modes in nanoparticle metamaterials

R. Sainidou and F. J. García de Abajo

Abstract: Surface modes in nanostructured metallic metamaterial films are reported showing larger confinement than plasmons in metallic waveguides of similar dimensions, but in contrast to plasmons, the new modes have TE polarization. The metamaterial, formed by planar arrays of nearly-touching metallic nanoparticles, behaves as a high-index dielectric for the noted polarization, thus yielding well confined guided modes. Our results for silver particles in silica support a new paradigm for TE surface-wave guiding in

unconnected nanostructured metallic systems complementary to TM plasmon waves in continuous metal surfaces.

12:30-14:00 Lunch

Session 17

EBG and photonic crystals II

Chaired by: Alex Schuchinsky

14:00-15:20

14:00 Dynamic visualization of wave packets interacting with periodic structures using sound on phononic crystals

O. B. Wright, D. M. Profunser, O. Matsuda, A. Khelif, V. Laude, S. Benchabane, and Y. Tanaka

Abstract: We demonstrate an ultrafast optical technique to track the propagation of surface acoustic wave packets on microscopic 2D phononic crystals in two dimensions. Diverse geometries involving arrays of holes in silicon are demonstrated, including the propagation in waveguides and cavities and reflection at boundaries. The dispersion relation and Bloch harmonics are elucidated. The results are compared and contrasted with similar results of other groups for photonic crystals.

14:20 Numerical model based on Plane-wave-expansion method for Lamb wave propagation in plate with phononic crystal layer coated on uniform substrate

Z. Hou, B. M. Assouar

Abstract: We proved that the lamb wave propagation in the phononic crystal (PC) plate coated on uniform substrate can be investigated by the revised plane wave expansion method. To use the plane wave expansion method, an imaginary infinite periodic system have to be constructed by stacking the studied plates and vacuum layers alternately in thickness direction (z), in which the Fourier series expansion can be performed. The difference between our imaginary periodic system and the infinite bulk wave PC is that, in our system, the Bloch feature of the wave along the thickness direction is broken.

14:40 Multifunctional Magnetophotonic Crystals Based on Magnetic Semi-conductors (Invited)

A. Granovsky, E. Ganshina, N. Perov, S. Erokhin, A. Orlov, A. Vinogradov, A. Lisyansky, S. Tarapov, and M. Inoue

Abstract: Recently, there has been intense searching for ferromagnetic ordering above room temperature in diluted magnetic semiconductors and oxides, focusing on possible spin-transport and magneto-optical properties, which have many potentially interesting applications in spintronics and magnetophotonics. We found above room temperature ferromagnetism and magneto-optical response in Mn-implanted Si and thin films TiO2: Co. It opens up new avenues for the development of novel metamaterials, such as magnetophotonic crystals, and advanced integrated magneto-optical devices. In the presentation we discuss recent theoretical and experimental results on magnetic and

magneto-optical properties of diluted magnetic semiconductors and based on them magnetophotonic crystals.

15:00 Mode Confinement in Periodic and Aperiodic PBG Cavities

E. Di Gennaro, S. Savo, and A. Andreone, G. Castaldi, V. Galdi, and V. Pierro

Abstract: We present a comparative (numerical and experimental) study of the confinement properties of finite-size periodic and aperiodic photonic band gap cavities with a point defect.

Session 18

Homogenization of metamaterials II

Chaired by: Alain Bossavit

14:00-15:20

14:00 Negative effective permeability and permittivity in ferroelectric rods array

T. Lepetit, E. Akmansoy, and J-P. Ganne

Abstract: In this work we have considered a square array of Baryum Strontium Titanate (BST) rods of square cross-section embedded in a polymer matrix in TE-mode. Effective permeability and permittivity were extracted and shown to take on negative values near zeroth-order and first-order resonances respectively.

14:20 Mixing Formulas and Plasmonic Composites

H. Wallén, H. Kettunen, and A. Sihvola

Abstract: Composites with plasmonic inclusions or holes in a plasmonic host medium can exhibit very interesting, or even extreme, properties. We compare the predicted effective permittivities of plasmonic composites using several classical mixing rules and quasistatic numerical simulations, and also briefly discuss some possible applications.

14:40 Effective parameters for metamaterials with magnetic inclusions

F. Pérez-Rodriguez, B. Zenteno-Mateo, and B. Flores-Desirena

Abstract: Exact analytic formulas for calculating the effective permittivity and permeability tensors for magneto-dielectric photonic crystals in the long-wavelength limit are presented. The formulas are valid for arbitrary Bravais lattice and form of the magnetic and dielectric inclusions. The dependence of these effective tensors upon the parameters of the magnetic inclusion is shown and analyzed.

15:00 Negative Refraction on the Lateral Surface of Semiconductor-Ferromagnet Superlattices at Quantum Hall-effect Conditions

R. H. Tarkhanyan and D. G. Niarchos

Abstract: The peculiarities of the wave refraction are investigated in superlattices consisting of alternating layers of ferromagnetic insulator and GaAs-AlGaAs-type semiconductor bilayers with two-dimensional electron gas system under quantum Hall-

effect conditions. It is shown that negative refraction on the lateral surface of the superlattice is possible in birefrigent regime.

Session 19

Metamaterials Design and Characterization II

Chaired by: Tatsuo Itoh

14:00-15:20

14:00 Fishnet and related metamaterials in microwave and optical frequencies

M. Kafesaki, Th. Koschny, E. N. Economou, C. M. Soukoulis

Abstract: The paper discusses the fishnet and modified designs and their negative index behaviour microwave and optical frequencies.

14:20 Tightly Coupled Planar Metallic Pairs as Metamaterial Basic Constituents (Invited)

A. Vallecchi, F. Capolino, and A. Schuchinsky

Abstract: A tightly coupled planar metallic pair can support even and odd modes of resonance. When exposed to the electric and magnetic fields it gives rise to artificial electricity and magnetism. Once the pairs are arranged in a periodic lattice, for example, they constitute a metamaterial in planar technology which can be characterized by effective permittivity and permeability. We discuss the principles underlying the properties of this kind of metamaterials made of coupled pairs and also provide the equivalent transmission line models quantifying their characteristics.

14:40 Double Elements Metamaterial with Negative Refractive Index at Infrared Wavelength

E. Pshenay-Severin, U. Hübner, J. Petschulat, C. Rockstuhl, T. Pertsch, F. Lederer, and A. Tünnermann

Abstract: The experimental realization of a metamaterial with the geometry of a unit cell based on the combination of double cut wires and continuous wire pairs, demonstrating negative refractive index at infrared wavelengths is presented.

15:00 SRR-like Microstructure of SrTiO3-TiO2 Eutectic – Its Microstructure and Transmission Properties

D*. A. Pawlak, K. Kolodziejak, S. Turczynski, K. Rozniatowski, F. Voltolina, P. Haring Bolivar, I. Vendik*

Abstract: Self-organization is one of a very attractive possibility for the cost effective manufacturing of metamaterials. In this presentation we demonstrate that even such complicated shapes as SRR-s can be grown by self-organization. In this work the microstructure of SrTiO3-TiO2 eutectic will be presented. The obtained microstructure is in the form of SRR-like particles made of TiO2 (rutile) with semiconducting properties. The size distribution of the SRR-like particles has an exponential character, and this may allow for a broadband behaviour. The SRR-like particles are embedded in the matrix of SrTiO3 with ferroelectric properties.

Session 20

Metamaterials: Fundamental Properties and Modeling I

Chaired by: Lucio Vegni

14:00-15:20

14:00 Dispersion Engineering: Beyond Negative Index of Refraction (Invited)

M. Mojahedi, S. Keser, S. Gharavi

Abstract: The paradigms of Dispersion Engineering will be discussed and connections among various terms such as indices, delays, and velocities will be established. Examples of media and devices for which the signs associated with various indices, velocities and delays can be independently and dynamically controlled will be presented and application of such devices in enhancing systems' functionalities will be discussed.

14:20 Design of Wide-Band Metamaterials Based on the Split Ring Resonator Model

A. Ahmed and M. A. Alsunaidi

Abstract: It is shown that the highly resonant characteristic of SRR can be significantly improved by introducing new pole pairs to Lorentz atomic model, and by adjusting their resonant frequencies and damping terms. A new SRR cell of metamaterial containing all these required poles is then designed for the desired bandwidth.

14:40 Nonlinear tunable microwave metamaterials

I. V. Shadrivov, A. B. Kozyrev, Y. S. Kivshar, and D. W. van der Weide

Abstract: We present what we believe is the first experimental demonstration of nonlinear left-handed metamaterials operating at microwave frequencies. We study experimentally a range of nonlinear phenomena including dynamic tuning of metamaterial resonant band, nonlinearity-induced transmission and harmonic generation.

15:00 Self Phase Modulation in Nonlinear Left-Handed Metamaterials

F. Fayazbakhsh, M. Akbari

Abstract: In this work, we tried to numerically analyze the propagation of a modulated high-amplitude gaussian wave packet in a nonlinear metamaterial semi-infinite region to observe LHM-SPM (esp. blue- and red-shifts). We, afterward, discuss the effect of dispersion on the propagation of packet envelope in the vicinity of nonlinearity.

16:00-20:00 Historical sightseeing tour of Marrakesh

Friday May 9, 2008

Plenary session 3

Chaired by: Sergei Tretyakov

08:30-10:30

08:30 **Keynote talk**

The Impact of Passive and Active Metamaterial Constructs on Electrically Small Radiating and Scattering Systems

R. Ziolkowski

Abstract: The impact of introducing active elements into metamaterial constructs for enhancing the performance of electrically small radiating systems at UHF and VHF frequencies and highly subwavelength scattering systems at optical frequencies will be presented.

09:00 **Keynote talk**

Engineering Optical Space: from Meta-Materials to Meta-devices

V. Shalaev

Abstract: Metamaterials are expected to open a gateway to unprecedented electromagnetic properties and functionality unattainable from naturally occurring materials, thus enabling a family of new “meta-devices”. We review this new emerging field and significant progress in developing metamaterials for the optical part of the spectrum. Specifically, we describe recently demonstrated artificial magnetism across the whole visible, negative-index in the optical range, and challenges along with promising approaches for accomplishing optical cloaking. The new paradigm of engineering space for light with transformation optics will be also discussed

09:30 **Keynote talk**

Metactronics: Optical Circuits and Information Processing in Nanoworlds

N. Engheta

Abstract: In my research group, we have been exploring fundamental concepts and various potential applications of metamaterials and plasmonic phenomena, for which these unconventional parameter values can play important roles. We have studied various metaplasmonic-based structures, devices, and nanocircuit, and have developed the concept of “metactronics” and meta-nanocircuits, i.e., “circuits with light at nanoscales”, in which the arrangement of a tapestry of plasmonic and nonplasmonic nanostructures can provide optical circuits in which the optical electric fields can be tailored in subwavelength regions. Indeed, “lumped” nanocircuit elements can be envisioned at the optical wavelengths. In my research group, a variety of ideas for nanocircuit functions, optical antennas for beam shaping and “photonic wireless at the nanoscale”, optical nanoscopy, nanospectrometer for molecular spectroscopy, nanotagging and barcodes based on meta-nanocircuits, and metamaterial-based supercoupling and EM energy squeezing through narrow subwavelength channels are being studied. In this talk, I will give an overview of these studies in my group, present physical remarks behind the findings, and forecast future ideas and potential applications in these areas.

10:00 **Keynote talk**

Negative Index materials: New Frontiers in Optics

C. Soukoulis

Abstract: The possibility of negative refraction has brought about a reconsideration of many fundamental optical and electromagnetic phenomena. This new degree of freedom has provided a tremendous stimulus for the physics, optics and engineering communities

to investigate how these new ideas can be utilized. Many interesting and potentially important effects not possible in positive refracting materials, such as near field refocusing and sub-diffraction limited imaging, have been predicted to occur when the refractive index changes sign. In this talk, I will review our own work on negative refraction in metamaterials, and describe the possible impact of them as new types of optical elements. In particular, I will present theoretical and experimental results on engineered microstructures designed to have both ε and μ negative.

10:30-11:00 Coffee break

Plenary session 4

Chaired by: Nader Engheta

11:00-13:00

11:00 **Keynote talk**

Metamaterials for Electronically Steered Beams

M. Tanielian

Abstract: One novel aspect of metamaterials is the possibility of having values of the index of refraction that are n < 1. This leads to new possibilities in the optics of electromagnetic beams. We have fabricated a number of negative index lenses using metamaterials and used them for steering electromagnetic beams as a simple alternative to more expensive phased array antennas. Phased arrays electronically steer a beam by adjusting the phase difference between adjoining waveguide elements of an array. However, due to impedance mismatches, most phased array antennas are limited in their scan angle to about 60 degrees from the vertical direction. In an effort to overcome this shortcoming, we have designed a metamaterial cover/dome for a phased array that allows scanning to angles which are almost 85 degrees from the vertical. We will discuss some of the tradeoffs one has to make to achieve these benefits and the limitations of such a system, when considering the traditional ring and wire-type metamaterials.

11:30 **Keynote talk**

Planar and cylindrical metamaterial structures for antenna applications

Y. Vardaxoglou

Abstract: *I*n situations where low-profile antennas in (principally but not exclusively) narrow band communications systems are needed, the use of resonant metamaterial structures are highly suitable. This is particularly useful for CP antennas where traditionally the BW is small. Cylindrical antennas are also shrinking in both length and radius by employing resonant metamaterials. This presentation will include a review of these concepts giving a few examples with measured data in the radio and microwave frequency range.

12:00 **Keynote talk**

Advances in Isotropic Metamaterial Design

R. Marques

Abstract: The problem of developing negative μ and negative refraction (NRI) 3D isotropic split ring metamaterials is addressed. First of all the necessary symmetries required to guarantee an isotropic behavior are analyzed. Secondly an homogenization procedure taking into account spatial dispersion is developed for magnetic split ring metamaterials. It is shown that this homogenization also accounts for all kind of waves (electromagnetic and magnetoinductive) previously reported in negative-μ split ring metamaterials. Finally, the possibility of developing isotropic NRI metamaterials from chiral split ring resonators (SRRs) is discussed in detail.

12:30 **Keynote talk**

Exhibition of gyrotropy in photonic crystals

A. Vinogradov, A M. Merzlikin, A V. Dorofeenko, A B. Granovsky, A A. Lisyansky, M. Inoue

Abstract: Photonic crystals consisting of magnetooptical materials (magnetophotonic crystal of MPC) often exhibit unusual magnetoptical properties. It is well-known that dilution of magnetooptical (MO) material, namely manufacturing MPC where the volume fraction of the MO material is significantly smaller than unity, may significantly enhance the MO Kerr, Faraday and magnetorefractive effects. In this communication, we focus our attention on 1D PC because of their comparative robustness in manufacturing and of their comparative insensibility to losses. We produce a unified explanation of the enhancement of MO effects in different resonant structures, such as MO defect in 1D PC, the Tamm state at the interface 1D PC-1D MPC, a slab of 1D MPC. It is also shown that some intracellular feature of the Bloch waves in MPC may lead to many effects unobserved in usual magnetoordered crystals: e.g. enhancement of MO effects, formation of new band gaps inside the Brillouin zones, the Borrmann effect in MPC.

13:00-14:30 Lunch

Session 21

Metamaterials for Antenna Technologies I

Chaired by: Yahya Rahmat-Samii

14:30-16:30

14:30 **Enabling True Wireless Broadband and Multi-Mode Comm. Networks with Metamaterial Air Interface Technology (Invited)**

M. Achour, A. Gummalla, C. J. Lee, A. Dupuy, G. Poilasne

Abstract: In this talk, we focus on transmission-line Metamaterials based on Composite Right Left Handed (CRLH) structures, which lend themselves easily to implementation in printed circuit board (PCB) structures. This class of Metamaterial not only supports this emerging System Integration Law targeting integration in small devices, but also offers ease of integration, at low cost, and high manufacturing tolerance and simplicity – all critical factors for rapid deployment and commercial success. During the presentation, we present Metamaterial applications to multi-mode phones and MIMO systems.

14:50 Three-dimensional Topology Optimized Metamaterial-inspired Electrically Small Antennas

A. Erentok and O. Sigmund

Abstract: Three-dimensional (3D) topology optimized metamaterial-inspired electrically small antenna designs are presented. Topology optimization is shown to provide the optimal placement of the available conductor material in a given space to maximize the far-field radiated power of an electrically small simple radiator.

15:30 Multi-frequency meta-surface based dipole antenna array (Invited)

E. Saenz, K. Guven, I. Ederra, E. Ozbay, and R. Gonzalo

Abstract: A multi-frequency meta-surface based dipole antenna array is experimentally investigated. It is formed by four dipoles resonating at a high frequency (HRF) and two other dipoles working at a lower frequency (LRF). The improvement in the mutual coupling between dipoles and in the radiation due to the presence of the meta-surface is analyzed by S parameters measurements and near-field scanning of the radiated field.

15:50 Application of Wire Media in Antenna Technology (Invited)

S. Hrabar

Abstract: This talk reviews the results of experimental investigation of radiating structures based on wire media with Drude-like dispersion, undertaken at University in Zagreb. It is shown that all three regions of the dispersion curve; the Epsilon-Negative (ENG) region, the Epsilon-Near-Zero (ENZ) region and the Epsilon-Positive (EPS) region can be successfully utilized in antenna applications. The specific examples include low-directivity radiator embedded into ENZ slab, the shortened horn antenna with embedded ENZ lens and the scanning leaky-wave waveguide antenna.

15:10 Beam and Frequency Agility Enhancement of a Microstrip Antenna through the Use of Metamaterials

H. Griguer, E. Marzolf, M. Drissi, and F. Riouch

Abstract: This paper presents a planar antenna making use of metamaterial technology in order to introduce beam and frequency agilities within the system. A microstrip patch antenna is inserted in a Fabry-Perot cavity made of a reflective surface on one side, and a semi-reflective surface on the other side, which permits the controlled radiation of the electromagnetic wave.

16:10 Resonant Properties of Plasmonic Split-Ring Nano-Antenna Using 2D FDTD

S. K. Valashani, M. Naghipourfard , K. Forooraghi and M. K. M. Farshi

Abstract: In this paper perturbed near-field electromagnetic properties of silver nano-split-ring and effect of split on electromagnetic properties of ring structure is investigated. The full vectorial method used in this simulation is based on finite difference time domain method. The goal of this paper is improvement of detection and emission of electromagnetic waves based on creation of gap in ring structures, this nano-structure can be used as an antenna in near-field microscopy.

Session 22

Metamaterial Applications and Devices I

Chaired by: Filippo Capolino

14:30-16:30

14:30 Multilayer Anisotropic Metamaterial Structure Applications

S. E. Lauro, A. Toscano and L. Vegni

Abstract: Multilayer structures are used in the design of thin-film antireflection coatings, dielectric mirrors, and optical interference filters, and in the design of broadband terminations of transmission lines. In this proposed contribution we will show if and how anisotropic metamaterials may lead to the realization of a new, improved class of components. This present work will study the performance characteristics of metamaterial multilayer structures in terms of the angular bandwidth and the reduction of electrical thickness.

14:50 SRR's High-Order Resonances in Waveguide and Free Space

M. Aznabet, M. Beruete, F. Falcone, M. Navarro, O. EL Mrabet, N. Aknin, M. Essaaidi, and M. Sorolla

Abstract: In this paper we introduce a novel planar frequency selective surface design based on Metamaterials. The proposed new design consists of a stacked complementary split ring resonators planar Metasurfaces separated by air which makes the fabrication simpler. Experimental results are presented and compared to those obtained from one CSRRs Metasurfaces, and show that higher band-passes become more selective and the lower band-pass becomes narrower as the number of the stacked CSRRs Metasurfaces increased. Furthermore, we present the cross polarization effect on the performance of the proposed design.

15:10 The Effect of Metamaterial Losses on DNG H-Guides

A. L. Topa, C. R. Paiva, and A. M. Barbosa

Abstract: This paper addresses the influence of the metamaterial losses, together with the metamaterial dispersion, on the performance of the double negative (DNG) H-guides. The lossy dispersive Lorentz model is adopted.

15:30 Miniature Low-loss Metamaterial Unit Cells Based on Grounded Spirals and Applications in Filter Design (Invited)

B. Jokanovic and V. Crnojevic-Bengin

Abstract: In this paper we present novel left-handed unit cells based on different combinations of grounded spirals: ForeS (four spirals connected in parallel), S-spiral, twin spiral and coupled twin spirals. All unit cells have small size that ranges from λg/13 to λg/59 and they exhibit very low insertion loss of about 1.4dB at resonance. Using the proposed unit cells, very compact and highly selective filters are designed and fabricated.

15:50 Tunable Narrow-band Filtering, Parametric Amplification and Mirrorless Oscillations in Doped Negative-index Materials

A. K. Popov, S. A. Myslivets, and V. M. Shalaev

Abstract. The unique properties of resonant four-wave mixing of backward waves in doped negative-index materials are investigated in the context of their applications for narrow-band filtering, amplification, and realizing miniature mirrorless optical parametric oscillators.

16:10 Double-Negative Metamaterial Optical waveguide Behavior Subjected to Stress

H. J. El-Khozondar, R. J. El-Khozondar and M. M. Shabat

Abstract: The focus of this study is on stress effect on the behaviour of optical waveguide sensor consists of dielectric slab inserted between metamaterial (MTM) cladding and substrate. Stress effect is investigated by using numerical calculations.

Session 23

Metamaterials: Fundamental Properties and Modeling II

Chaired by: Mo Mojahedi

14:30-16:30

14:30 Exchange-coupled nanocomposite magnets - Metamaterials for energy (Invited)

J. P. Liu

Abstract: In addition to optical applications, metamaterials find applications in energy storage and conversion. Exchange-coupled nanocomposite (or exchangespring) magnets are a class of metamaterials for energy applications. In this presentation we introduce synthesis and processing of exchange coupled nanocomposite magnets through a bottom-up approach. By using novel techniques, the hard/soft nanocomposite magnets with enhanced energy products have been successfully produced.

14:50 Effect of the negative refraction on Anderson Localization

A. A. Asatryan, L. C. Botten, M. A. Byrne, V. D. Freilikher, S. A. Gredeskul, Y. S. Kivshar, R. C. McPhedran, I. V. Shadrivov

Abstract: It is shown that incorporation of elements with negative index of refraction can suppress significantly Anderson localization of light in one-dimensional disordered systems. This effect depends on the type of the disorder and manifests itself in the increase of the localization length and vanishing of the disorder-induced resonances. We attribute these results to the inability of waves to accumulate phase, which leads to weak interference action within the structure.

15:10 Trapped-Mode Resonances in Isotropic Planar Metamaterials (Invited)

S. L. Prosvirnin, V. A. Fedotov, S. Zouhdi, and N. I. Zheludev

Abstract: We propose a new type of planar metamaterials that can support high-Q electro-magnetic modes, namely trapped modes, excitation of which is polarization insensitive.

15:30 Bounds for Metamaterials - Theoretical results

G. Kristensson, C. Larsson, C. Sohl, and M. Gustafsson

Abstract: A dispersion relation for the combined effect of scattering and absorption of electromagnetic waves is presented for a large class of linear and passive material

models. By invoking the optical theorem, the result states that the extinction cross section integrated over all frequencies is related to the static polarizability dyadics. In particular, it is established that the extinction cross section integrated over all frequencies is the same for all materials having the same static electric and magnetic properties, irrespectively whether the permittivity or the permeability have negative real parts at non-zero frequencies or not.

15:50 The dispersion relation of light in metamaterials: An analytical approach

J. Petschulat, C. Menzel, C. Rockstuhl, A. Chipouline, T. Pertsch, and F. Lederer

Abstract: An analytic approach to describe the plane wave propagation in metamaterials at the example of the double wire structure is presented. Based on simple considerations of the charge dynamics analytical expressions for the dispersion relation, magnetization and the electric displacement are derived and effective material parameters – permittivity and permeability – are elaborated. Results from the analytical model are compared to results from rigorous simulations.

16:10 Application of the TLM Wire-Symmetric Condensed Node (W-SCN) for modeling metamaterial media (Invited)

E. Hamham, M. Khalladi, M. I. Yaich and F. L. Messa

Abstract: This paper presents the modeling of Metamaterial media using the TLM with the symmetric condensed node (SCN) with wire. In our case, this medium is a flat subwavelength lenses formed by an array of parallel metallic wires which is modeled in a TLM lattice by two Wire-SCN approaches.

16:30-17:30 Coffee break & Poster session III

Poster session III

Chaired by: Olivier Dubrunfaut

16:30-17:30

C1 Propagation and Focusing of Spoof Surface Plasmon Polaritons through Perfectly Conducting Plates with Lamellar Grating at Terahertz Frequency

S.-H. Kim, J.-E. Kim, and H. Y. Park

C2 Photonic Band Structure of a Superlattice Composed of Left Handed and Right Handed Materials

D. Bria, A. Essadqui , M .El Ouariachi, B. Djafari-Rouhani and A. Nougaoui

C3 Fast Hybrid BI/BI Modeling of Complex 3D Biperiodic Structures

S. Nosal, P. Soudais and J.-J. Greffet

C4 Homogenization by Periodic Unfolding Method in Frequency Domain for Bianisotropic Metamaterials

H. Belyamoun, L. Santandrea, S. Zouhdi, O. Ouchetto and O. Dubrunfaut

C5 **Application of a combination of the Multilevel Fast Multipole and the characteristic Basis Function Methods to the Analysis of Metamaterials**

F. Cátedra, I. Gónzalez, C. Delgado, E. Garcia

C6 **EBG materials in printed antenna designs: Novel structure for Antenna miniaturization**

M. Elayachi, P. Brachat, J.-M. Ribero

C7 **Size reduction of the planar microwave devices by using metamaterials**

M. G. Banciu, N. Militaru, and G. Lojewski

C8 **Towards High-power Metamaterial-based Scanning Leaky-wave Antenna for Plasma Physics Applications**

S. Hrabar, Helga Kumric, D. Zaluski

C9 **Electromagnetic bandgap calculations of Tb3Sc2Al3O12-TbScO3 eutectic with self-organized rod-like microstructure**

A. Della Villa, F. Capollino, B. Lahiri, N. P. Johnson, S. Turczynski, D. A. Pawlak

C10 **Two Full-Vector Methods for Calculating the Modes in Bragg Fibers**

Y. O. Shuyupova and V. V. Kotlyar

C11 **Investigation into the sensitivity of Electrical Base-Band Memory Effects to higher order IF components for High-Power LDMOS Power Amplifiers**

A. Alghanim, J. Benedikt and P. J. Tasker

C12 **Development of Magnetic Super Conducting Material In an Inhomogeneous Magnetic Field at Room Temperature**

S. K. Ghosh and A. Ghosh

C13 **Study and Analysis of Dielectric Constant, Stress-Polarization relation with Applied Electric Field on Structural, Electrical and Thermal Properties**

R. Kushal

C14 **Effect of the excess of Mg and Si on AlMgSi alloys**

F. Serradj, R. Guemini, S. Hamamda

C15 **3D Modelling Of The Electric Field inside a GaAs Semi-Insulating P+-v-N+ Structure**

B. Benichou, B. Bouabdallah, R. Menezla, Y. Bourezig, J. Mamoun

C16 **Ab-initio calculations of the CdTe/ZnTe layers surface energy**

B. Rerbal, G. Merad, H. Mariette, and J-M. Raulot

C17 **A necessary of Xor linear code with generator matrix in quantum communications protocols**

S. Aris, N. Merabtine, and M. Benslama

C18 **Boundary Line of Microcrystallines in Amorphous and Crystalline Structures of Metallic Glasses**

K. Habib

Session 24

Metamaterial Applications and Devices II

Chaired by: Silvio Hrabar

17:30-18:50

17:30 Nonlinear properties of SQUID Metamaterials

C. Du , H. Chen, and S. Li

Abstract: We investigate the permeability of superconducting-quantum-interfere-devices metamaterials for a microwave probe field, and derive the frequency spectrum of permeability and physical conditions for negative (real part) permeability.

17:50 A Design for Ultracompact Waveplates using Metamaterials

M. Iwanaga

Abstract: An ultracompact waveplate (UCW) is numerically demonstrated using photonic metamaterials. It works highly efficiently to realize λ/4- and λ/2-plates in subwavelength dimensions. For the light of 400 nm, the thickness is only 135 nm for a λ/4-plate and 285 nm for a λ/2-plate. The UCW is one of the realistic good applications using low-loss metamaterials at optical wavelengths and will be a crucial element in photonic integrated circuits.

18:10 Robust plasmon waveguides in nanowire arrays

A. Manjavacas and F. J. García de Abajo

Abstract: Arrays of parallel metallic nanowires are shown to provide a tunable, robust, and versatile platform for plasmon interconnects, including high-curvature turnings with minimum signal loss. Guiding through gap plasmons existing in the region between adjacent nanowires is shown to be realizable over distances of tens of microns in straight and curved wire dimers, as well as in multi-wire arrays. Our study can find application in the design of plasmon-based interconnects and provides the tools for achieving high degree of integration with minimum cross talk between adjacent plasmon guides.

18:30 Electromagnetic surface waves in a metamaterial-magnetic waveguide structure

H. Mousa and M. M. Shabat

Abstract:The growing and rapid interest in new artificial metamaterials, whose properties differ from the normal materials has motivated further investigations. The metamaterials have simultaneously negative permittivity and permeability. In this work, we have demonstrated theoretically the existence and behavior of the TE surface and guided waves in a Ferromagnetic/Metamaterial/ Antiferromagnetic waveguide structure. The dispersion characteristics are performed for different kind of metamaterials.

Session 25

Metamaterials: Fundamental Properties and Modeling III

Chaired by: Richard Ziolkowski

17:30-18:50

17:30 Geometrical transformations for numerical modeling and for new material design in photonics (Invited)

A. Nicolet, F. Zolla

Abstract: This paper is a review of various techniques used in computational electromagnetism such as the treatment of open problems, helicoidal geometries and the design of arbitrarily shaped invisibility cloaks. This seemingly heterogeneous list is unified by the concept of geometrical transformation that leads to equivalent materials.

17:50 Effects of SRR density on the effective permeability

C. Amabile and E. Prati

Abstract: We present a study of the properties of radiation transmitted through a SRR metamaterial as a function of the SRR density in WR90. We show that such parameter significantly affects the value of the effective permeability of the metamaterial.

18:10 A Novel Frequency Selective Surface Design based on Metamaterials

M. Aznabet, O. EL Mrabet, M. Beruete, F. Falcone, M. Navarro, N. Aknin, M. Essaaidi, and M. Sorolla

Abstract: In this paper we introduce a novel planar frequency selective surface design based on Metamaterials. The proposed new design consists of a multiple printed planar layers, which makes the realization rather easier. It is shown that this FSS has narrow and wideband multi-frequency response in case of copolar polarization. Simulation and measurement results of the proposed design are presented and analyzed.

18:30 Chiral Isotropic Metamaterials with Negative Refractive Index

N. Wongkasem and K. Matra

Abstract: In this paper, novel chiral isotropic metamaterials with negative refractive index are proposed. Group Theory is used to determine the material parameters of various designed structures. It has been demonstrated that structures in the point groups C3-C8 and D2-D8 are isotropic and chiral.

Session 26

Metamaterials for Antenna Technologies II

Chaired by: Mahbub Hoque

17:30-18:50

17:30 Radar Cross-Section of Targets Loaded with Metamaterial

B. H. Henin, M. H. Al Sharkawy, and A. Z. Elsherbeni

Abstract: A rigorous semi-analytical solution is presented for electromagnetic scattering from an array of parallel-coated circular cylinders of arbitrary radii and positions due to an obliquely incident plane wave excitation. Circular metamaterial cylinders/cylinders with metamaterial coating are then used to show the effect of metamaterial characteristics in altering the forward and backward scattering cross-section of arbitrary shaped two dimensional targets. Furthermore, characteristics of metamaterial are used to enhance or reduce the scattered field in pre-specified directions.

17:50 Plasmonic near-field phase antennas

A. G. Curto and F. J. García de Abajo

Abstract: A rigorous semi-analytical solution is presented for electromagnetic scattering from an array of parallel-coated circular cylinders of arbitrary radii and positions due to an obliquely incident plane wave excitation. Circular metamaterial cylinders/cylinders with metamaterial coating are then used to show the effect of metamaterial characteristics in altering the forward and backward scattering cross-section of arbitrary shaped two dimensional targets. Furthermore, characteristics of metamaterial are used to enhance or reduce the scattered field in pre-specified directions.

18:10 Beam Shaping of Millimeterwave Antennas using Freeformed Ceramic Meta-materials

Y. Lee, X. Lu, Y. Hao, S. Yang, J. R. G. Evans, and C. G. Parini

Abstract: In this paper, we present the electromagnetic characteristics of the freeformed EBG structures with controlled defects and their applications for antennas at millimeterwave bands. A low profile directive antenna for security imaging and wireless data link is demonstrated. The designed antenna utilizes a planar woodpile EBG structures for realizing a narrow beam at 95 GHz. We present for the first time the fabrication of cylindrical woodpile structures using ceramic extrusion freeforming technique and several designs of directive fan-beam antennas for high data rate indoor wireless communications.

18:30 Near-Field Probes using Double and Single Negative Media

M. S. Boybay and O. M. Ramahi

Abstract: A sensitivity definition is made for evanescent field probes and the effects of using single negative (SNG) and double negative (DNG) metamaterial slabs are analyzed. It is found that SNG and DNG metamaterials increase the sensitivity of detection. Evanescent field transmission through DNG and SNG layers are compared and the sensitivity improvements obtained by DNG and SNG layers are discussed by paying attention to their response to different incident evanescent fields. It is shown that matched DNG layers increases the sensitivity of whole evanescent spectrum with improved enhancement for higher decay constant evanescent fields. In the case of SNG and unmatched DNG layers, the sensitivity improvement is limited by the singularity observed in the transmission behavior of SNG and unmatched DNG layers. These findings lead to a new paradigm in designing near-field based probes using SNG and DNG media.

20:00-23:00 Conference banquet

Saturday May 10, 2008

07:30-20:00 Excursion to Essaouira

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