Surface Multiplasmonics and All-Dielectric Surface-Wave Propagation

Overview

Research on electromagnetic surface waves has a rich history extending back to the early era of radio, when the concept of ground-wave propagation was initiated by Tesla and developed by Zenneck and Sommer field among others. Today, surface-plasmon-polariton (SPP) waves are routinely used for optical sensing of pharmaceutical products, pesticides, chemicals and biochemicals, disease agents (including toxins, bacteria, and viruses), and explosives, as well as to monitor chemical reactions. SPP waves are also exploited for microscopy and communication. The research area is called *surface plasmonics*.

An essential requirement for SPP-wave propagation is that the real parts of the relative permittivities of the two partnering materials be of opposite signs. Therefore, in the infrared, visible, and ultraviolet regimes, the SPP wave is guided by the planar interface of a metal and a dielectric material. Typically, both are assumed to be isotropic and homogeneous. At a given frequency, only one SPP wave can be excited. Its phase speed, attenuation rate, degree of localization to the interface, and field profile are determined by the electromagnetic properties of the two partnering materials and do not depend on the direction of propagation in the interface plane. If the partnering dielectric material is anisotropic (such as a solid crystal or a nematic liquid crystal), the SPP wave's characteristics do depend on the direction of propagation in the interface plane, but still only one SPP wave can be excited at a given frequency.

This course will present the methodology of formulating and solving for SPP waves guided by the interface of a metal with a periodically non-homogeneous dielectric material such as a photonic crystal or a sculptured thin film. Such interfaces can support more than one SPP wave at the same frequency but with different phase speeds, attenuation rates, and degrees of localization to the interface. The research area called *surface multiplasmonics* has come into existence in 2008. The multiplicity of SPP waves has been experimentally verified, and the phenomenon is being developed for optical sensing and other purposes.

Other electromagnetic surface waves do not require one partnering material to be a metal. Such surface waves are guided by the planar interface of two dissimilar dielectric materials. The techniques used in surface plasmonics and surface multiplasmonics can also be adapted for all-dielectric surface-wave propagation. These types of electromagnetic surface waves are Tamm waves, Dyakonov-Tamm waves, and Uller-Zenneck waves. Whereas Uller-Zenneck waves underlie ground-wave propagation, applications of Tamm waves and Dyakonov-Tamm waves are beginning to emerge.

Goal and Objectives

The goal of the course is to make the participants aware of the basic machinery of electromagnetics used for research on electromagnetic surface waves. This goal will be accomplished through two objectives. The first objective is to learn the design principles and analysis of the prism-coupled configuration and the grating-coupled configuration for surface multiplasmonics. The second objective is to apply the same techniques to Tamm waves, Dyakonov-Tamm waves, and Uller-Zenneck waves.

This course will enable the participant to:

- formulate and numerically solve the *canonical* boundary-value problem of surface-wave propagation guided by the interface of two linear materials;
- identify the basic property of the partnering dielectric material that results in more than one SPP wave of the same frequency but of different phase speeds, polarization states, degrees of localization, and field profiles;
- set up and solve the prism-coupled configurations for the excitation of multiple SPP waves at the interfaces of a metal and a sculptured thin film or a photonic crystal;
- use the rigorous coupled-wave approach to elucidate the excitation of multiple SPP waves in the grating-coupled configuration;
- apply surface multiplasmonics in designing optical sensors, planar optical concentrators, and thin-film solar cells; and
- apply the same formalisms for other types of electromagnetic surface waves including Tamm waves, Dyakonov-Tamm waves, and Uller-Zenneck waves.

Modules	**Surface Multiplasmonics and All-Dielectric Surface-Wave Propagation: December 19 - December 27, 2016** **Number of participants for the course will be limited to forty (40).**
You Should Attend If…	• Scientists, engineers and researchers from manufacturing, service and government organizations including R&D laboratories, especially engineering/science departments, such as physics, electronics engg and electrical engg, as well as from allied and interdisciplinary disciplines such as food engg and analytical chemistry • Students at all levels (B.Tech./M.Sc./M.Tech./Ph.D.) • Faculties from IITs and other reputed academic and technical Institutions of India.
Fees	The participation fees for taking the course is as follows: **Participants from abroad : US $500** **Industry/ Research Organizations: Rs. 10000** **Academic Institutions: Rs.5000** **Students: Rs. 1000** The above fee include all instructional materials, computer use for tutorials and assignments, laboratory equipment usage charges, 24 hr free internet facility. The participants will be provided with single bedded accommodation on payment basis.

Prof. Akhlesh Lakhtakia obtained a Bachelor of Technology degree in Electronics Engineering from the Banaras Hindu University, Varanasi, India in 1979; Master of Science and Doctor of Philosophy degrees in Electrical Engineering from the University of Utah, Salt Lake City in 1981 and 1983, respectively; and a Doctor of Science degree in Electronics Engineering from the Banaras Hindu University in 2006. In 1983, he joined the faculty of the Pennsylvania State University, where he was elevated to the rank of Distinguished Professor of Engineering Science and Mechanics in January 2004. In 2006, he became the Charles Godfrey Binder (Endowed) Professor of Engineering Science and Mechanics. He also serves as a Professor in the Graduate Program in Materials.

Dr. Lakhtakia has published more than 800 journal articles; has contributed 27 chapters to research books and encyclopedias; has edited, co-edited, authored or co-authored 19 books and 22 conference proceedings; has authored or co-authored 305 conference papers. He is a Fellow of the Optical Society of America (1992), SPIE (1996), the UK Institute of Physics (1996), the American Association for the Advancement of Science (2009), the American Physical Society (2012), IEEE (2016), And Royal Society of Chemistry (2016). For his research on sculptured thin films and complex-medium electromagnetics, received the Faculty Scholar Medal in Engineering in 2005 from the Pennsylvania State University, the 2010 SPIE Technical Achievement Award, and the 2016 Walston Chubb Award for Innovation. Nanotech Briefs recognized him in 2006 with a Nano 50 Award for Innovation.

His current research interests lie in the electromagnetics of complex materials including chiral and bianisotropic materials, sculptured thin films, nanoengineered metamaterials, surface multiplasmonics, engineered biomimicry, bone nano-refacing, and forensic science. His research accomplishments have been discussed on CNN, and in a NOVA movie as well as covered on several scientific media outlets.

Prof. Pradip K. Jain has joined as a faculty of Electronics Engineering at Institute of Technology, Banaras Hindu University in 1981, and currently working as Dean, Research and Development of Indian Institute of Technology (BHU), Varanasi. He also served as Coordinator of the Centre of Research in Microwave Tubes, Coordinator, Center of Advanced Study, as well as Head of Department of Electronics Engineering, IIT (BHU).

Prof. Jain has successfully executed a number of sponsored research projects. His current research interests include high power microwave devices and circuits. He has published more than 100 research papers in SCI journals and 200 in the conference proceedings besides guiding 15 doctoral theses.

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