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Greek Presidency
(1 January-30 June 2003)

Spotlights

New Laser Technique for Controlled Doping of Thin Films with Impurity Atoms

The new technique that is based on pulsed laser deposition (PLD), allows the control of the concentration and distribution of impurity atoms into thin film semiconductive nanostructures. It was developed by a research team lead by Dr. Michalis Kompitsas at the Institute of Theoretical and Physical Chemistry of the National Hellenic Research Foundation (ITPC/NHRF) in Athens, in cooperation with the Institute of Nuclear Physics of Bucharest, Romania. The new method was presented in an article published in the German technical magazine PHOTONIK (April 2005), which specializes in industrial applications of optical technologies. This particular article was also presented in the magazine's special edition, titled "(best of) PHOTONIK international 2006", which includes, translated in English, the best technical articles published in 2005.

Thin film technology is now the basis for several areas of the optoelectronic industry. Its applications range from TFT monitors, photovoltaic and thermo-electrical elements and toxic gas detectors development to telecommunication applications, as two-dimensional waveguides, laser optical amplifiers, LEDs etc. Doping of foreign elements into thin films plays an essential role in changing the morphological (e.g. crystallinity), electrical (conductivity) and optical (absorption/reflection, luminescence emission) properties of the thin films. The need to optimise all of the above parameters for each specific application is obvious. This need makes controlled doping with foreign atoms as impurities an important part of the production procedure for such nanostructures.

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Today there are numerous thin film deposition techniques; most common are chemical vapour deposition (CVD), sputtering, molecular beam epitaxy (MBE) and the PLD method that has been developing rapidly during the past years. The main characteristics of the PLD method are its simplicity and the fact that it can be applied to deposit almost any material. Its operating principle is based on focusing a powerful pulse laser on a target, resulting in the evaporation of a part of the material's surface. The particles travel a distance of a few centimetres under high vacuum conditions and deposit themselves on a heated or non-heated substrate (silicon, glass or other). Thus, with each laser pulse the film is formed by successive layers of material. An interesting category of thin films produced using PLD are metal oxides because they are transparent and have a small electrical resistance; these properties are useful in many optoelectronic applications.

In most cases and for the reasons mentioned previously, doping of foreign atoms is performed after the deposition, by bombarding the film with beams of fast moving ions. Apart from the cost and the complexity of the device, there is the risk of the film lattice being destroyed by the ions, and the film surface being contaminated during the transfer from the deposition area to the doping device. Furthermore, controlling the distribution of doping atoms is difficult and the whole process is limited to single-layer (namely single type) film, while it does not apply to multi-layered structures where each layer may have different requirements for the foreign atom concentration.

All these problems are solved by doping during deposition, as is the case with the MBE method. However, current MBE devices are very expensive. They have high requirements from the pumping system, due to the high temperatures that are necessary for the operation of the atomic beam furnaces; they require complex moving mechanical parts in the deposition chamber and are characterised by high material consumption.

The method developed by the Greek research team at ITPC/NHRF is a "combination" of the PLD and MBE deposition methods without the drawbacks of the latter. It should be noted that many attempts to doping impurities using PLD have already been made in the past using pre-mixed (composite) targets. Apart from the cost of manufacturing each target with the required ratio, it has been proven that the film's stoichiometry was not always identical to that of the target. On the contrary, the new method bypasses these problems by using two independent and synchronized pulse lasers and two targets.

The first "powerful" laser with a constant energy pulse is used to deposit the host-lattice, while the second laser is used to ablate the impurity material target into the lattice. Thus the "laser beam - target" system is equivalent to an atomic beam source of the MBE method. By controlling the beam energy of the second

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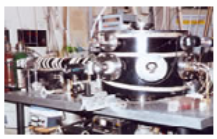

The ITPC/HNRF laboratory uses two pulse lasers capable of emitting a beam in the infrared (IR), visible (VIS) and ultraviolet (UV) range of the spectrum. This provides great flexibility regarding the ability to select both the wavelength and pulse energy, depending on the optical properties of the targets. The complete deposition assembly is complemented by a mobile base inside the deposition chamber, where different targets are placed; the targets can be selected in pairs using a computer. Thus it is possible that multilayer structures are deposited, each layer with different composition and impurity, only by selecting the laser parameters during deposition (in real-time). The latter is quite important, as the time for depositing complex structures is minimised and interface contamination between different layers is avoided.

According to Dr. M. Kompitsas the above technique was successfully applied for the first time at the ITPC/NHRF on a zinc oxide film doped by aluminium atoms. ZnO was selected because of the big interest expressed recently for this particular oxide, due to its significant electro-optical properties for industrial applications. As the ITPC researcher points out: "This is an innovative technique which can be in principle applied for depositing any material into any film. For this reason the article introducing this method was selected as one of the best articles of the PHOTONIK magazine for 2005."

Institute of Theoretical and Physical Chemistry / NHRF
http://www.eie.gr/nhrf/institutes/tpci/index-gr.html

PHOTONIK magazine
http://www.photonik.de/

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Around Europe
Greek researchers lead the way on thin film technology
Thin film technology is key to many areas of the optoelectronic industry, having applications in photovoltaic and thermo-electrical elements, toxic gas detectors and telecommunications. The morphological, electrical and optical properties of the films can be altered by the careful deposition onto the film of 'impurity' atoms. Now a team of Greek and Romanian researchers has developed a new deposition method which gives researchers greater control over the quantity and placing of the impure atoms.
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The site also outlines the Greek participation in European R&D programmes, including research projects, exploitable results and technological offers, in order to stimulate the links with the market. Moreover, it offers information on funding opportunities, key figures, official documents, national contacts and links to research institutions, universities, IRCs and more. This interface will be helpful for following the implementation of the Sixth Framework Programme (FP6) and new initiatives to make the enlarged European Research Area (ERA) a reality.
Highlights
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The Greek CORDIS web service, regularly updated and available in English and Greek, provides comprehensive coverage of current R&D issues, announcements of forthcoming events, interviews with key figures, publications and selected features periodically placed under the spotlight. By providing accurate and timely information, the site helps broaden the understanding of R&D and Innovation activities, enhances the participation in national and EU programmes and encourages a closer cooperation of the scientific, academic and business communities.
R&D Events
11-14 June 2006, ISPIM 2006 Conference: "Networks for Innovation", Athens
5-7 July 2006, International Conference on Telecommunications & Multimedia, Crete
20-23 September 2006, International Conference on Information Systems in
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