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Self-organized periodic nanostructures on the surfaces of semiconductors and dielectrics by scanning femtosecond laser pulses

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We report the self-formed nanogratings on the surfaces of semiconductors (ZnO and GaN) and dielectric materials (fused silica, borate glass, $LiTaO_3$, $LiVO_3$, sapphire) prepared by scanning focused femtosecond laser pulses at 800 nm with a repetition rate of 1 kHz. Laser fluence range for nanograting self-formation is very narrow. We found that series of periodic-structure orientation is perpendicular to the linear laser polarization. The period of grating structures on the dielectric surface depends on laser power and scans speed and increases in the range of 200~300 nm with scan speed and laser pulse energy. In contrast, GaN shows about 600 nm period in the same power range as the dielectric materials. Its period decreases to 450 nm when the laser power is reduced ten times. It also has much lower laser ablation threshold than dielectrics and ZnO, indicating characteristics of metal-like nanogratings due to its high plasma density, large thermal conductivity, and multiphoton absorption coefficients at 800 nm. Emission from nanograting area of sapphire indicates the existence of oxygen vacancies. Figure 1 shows the nanograting structure formed by scanning femtosecond laser pulses at 40 μm/s speed on the surfaces of $LiVO_3$ and ZnO with 0.13 and 0.09 mW power respectively. For applications, surface nanostructures can be used to improve out-coupling of light in LED. Material absorption can be also significantly enhanced due to surface nanostructures produced by fs-laser pulse processing, applicable to sensing and solar cells.

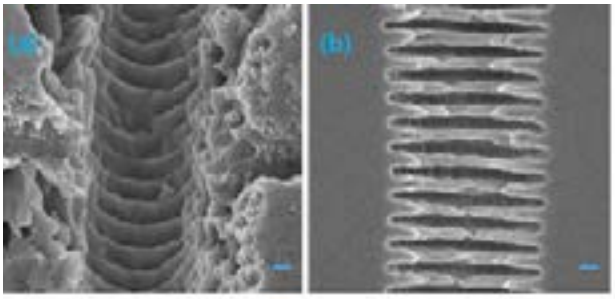

Figure 1. SEM images of self-formed nanogratings on the surfaces of $LiVO_3$ dielectric (a) and ZnO semiconductor (b). Scale bar: 200 nm.

Biography

Ki-Soo Lim is a Professor of Physics Department at Chungbuk National University, South Korea. He has been working on Laser Spectroscopy of rare-earth ion doped crystals, glasses, glass-ceramics, and semiconductors. He also studied 3-D bit or holographic data storage in glass, photopolymers and photovoltaic materials. His recent interests and achievements include precipitation and optical properties of glass-ceramics containing fluoride nanocrystals, and micro-nanostructure fabrication on the surface of dielectric materials and polymers by femtosecond laser. He received his BS and MS degrees in Physics at Seoul National University in 1977 and 1980 respectively. He then did his PhD in Physics at University of Connecticut, USA and worked at University of Georgia as a Research Associate. He joined Chungbuk National University in 1990 after working at Korea Standard Research Institute..

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