Seminar

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Institute for Plasma Research

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Title: Formation and Characterization of N_2 Nanosecond Pulsed Laser Induced Black Silicon (LibSi) For Optoelectronics Application

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Abstract

The semiconductor material Silicon (Si) is widely applicable in various fields of optoelectronics such as, photodetectors, surface enhance Raman spectroscopy (SERS) chip, field emission and solar cells, etc. However, the high surface reflectance of traditional bulk silicon restricts the full use of the incident radiation. To overcome this demerit, several techniques of texturing and micro/nano structuring have been implemented to enhance the absorption of light on Si surface. There are several types of surface structures, among them the black silicon is the most competent and extensively used. As the light absorption capability of the optoelectronic devices are considerably improved when its surface is coarse or textured in place of smooth. In such textured Si surface, the reflectivity is reduced drastically so as to provide higher incident radiation absorption resulting the higher efficiency. In this work, we have used the direct laser texturization method to generate such micro/nanostructures for realization of the Black Si. To carry out these laser texturization work we have developed a compact laser workstation attachment (LWA) system integrated with optomechanical mounts, beam delivery optics, motion control hardware and software etc, except the laser sources unlike the existed conventional laser workstation. It can be interfaced to any kind of laser sources; it is compact in size and hence easily portable. It can be used for various conventional material processing applications as well generation of laser induced periodic surface structures (LIPSS), laser induced black Silicon (LibSi) and microgroove based LibSi etc. In this work an intensive study has been done using low-cost laser like nanosecond (ns) pulsed Nitrogen (N_2) gas laser for growth of LibSi on large area Si surface in air. An investigation has been carried out on the experimental parameters effect on the morphological behaviour of micro/nanostructured Si surface and suggested a mechanism for formation of large area micro/nanostructured Si. Further in the proper processing parameters optimization the works have been done on the formation of LIPSS on Si (SiLIPSS), microgroove based LibSi and LibSi on large area Si surface. The particular studies have also been done on the grown sub-wavelength SiLIPSS using ns N_2 gas pulsed laser. In the field emission studies (FESEM) it has been found that LIPSS periods are much less than the wavelength i.e., ~$\lambda/9$ times of the irradiated laser wavelength (337nm). The total reflectance behavioural study has been done on grown LibSi surface using a UV-visible spectrophotometer attached with an integrating sphere. From this study, it is found that reflectance of LibSi surface in an optimized condition can be as low as to 10% for a broad wavelength range. For an optoelectronics application I have worked on fabrication and characterization of surface enhanced Raman spectroscopy (SERS) chip on grown LibSi. From the Raman spectra study, the Raman enhancement effect was found to be ~12 times higher in the LibSi/Ag SERS chip relative to polished Si/Ag substrate. These outcomes indicate that the LibSi/Ag SERS chip has potential applications.