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FORMATION OF MICRO - NANOSTRUCTURES ON THE Si SURFACE USING LASER

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Recently, nonlinear interactions between ultrashort laser pulses and semiconductors have opened new avenues in the field of laser micro- nanofabrication [1]. Experimental studies of the features of the formation of laser-induced periodic surface structures (LIPSS) on the surface of silicon wafers in the zone of action of millisecond and nanosecond laser pulses are conducted in the work. The results of microscopic investigations by optical and electron microscopes of periodic structures formed on the Si surfaces with crystallographic orientation (111), (100) are presented. Different types of periodic structures were obtained, such as straight parallel lines, concentric circles, micropyramids with square and triangular bases. Straight parallel lines are formed by irradiation of the specimen at an angle of 10º from the perpendicular. Such a structure in the form of straight parallel lines is a consequence of the interference between the incident and the electromagnetic wave reflected from the lower boundary of the sample surface melt. The period of the pair lines of these microstructures is 2 μm, which correlates with the laser wavelength of 1.06 μm Nd:YAG laser. Concentric circles, which in some cases are observed on the surface of irradiated silicon, differ in diameter from one to tens of microns. They can be explained by the formation of so-called plasmonic lenses on the surface of a semiconductor at a certain density of laser radiation energy. The formation of micropyramids is due to the fact that, with the uniform excitation of semiconductors, laser radiation with a threshold power locally molten zones are formed on irradiated surfaces. Those zones reproduce the distribution of the concentration of nonequilibrium charge carriers, modulated by the intracrystalline field according to the symmetry of the crystal. It is established that the shape of local float holes is uniquely related to the crystallographic orientation of the semiconductor surface [2]. In this case, triangular square holes of floodplains are formed on the plane (111) and square ones on the plane (100). Both the individual micropyramids and the accumulation of micropyramids in the form of surface periodic structures were observed on the surface of the test samples throughout the sample surface. The obtained results can be used to optimize the laser pulse mode for controlled micro- nanostructuring of the semiconductor surface. Thus, the

structural shape of the LIPSS can be manipulated by changing the optical parameters of laser, such as incident angle, polarization and input wavelengths.

1. *Venger Ye. F., Semchuk O. Yu., Havrylyuk O. O.* Lazer-indukovani nanostruktury v tverdykh tilakh. – Kyiv: Akademperiodyka, 2016. – 236 p.
2. *I.A. Mohylyak, O.Yu. Bonchyk, S.A. Korniy, S.G. Kiyak, D.I. Popovych.* Laser Formation of Periodic Micro- and Nanostructures on the Surface of Monocrystalline Silicon // Physics and Chemistry of Solid State. – 2020. – V.21(2). – P. 215-218.

ФОРМУВАННЯ МІКРО- НАНОСТРУКТУР НА ПОВЕРХНІ КРЕМНІЮ ЗА ДОПОМОГОЮ ЛАЗЕРА

Проведено експериментальні дослідження особливостей утворення лазер-індукованих періодичних наноструктур на поверхні монокристалічного кремнію в зонах дії мілісекундних і наносекундних лазерних імпульсів. Наведені результати мікроскопічних досліджень оптичним і електронним мікроскопом періодичних структур, які формуються на поверхнях з кристалографічною орієнтацією (111), (100). Одержані результати можуть бути використані для оптимізації режиму імпульсного лазерного випромінювання з метою контрольованої зміни структурних параметрів LIPSS для наноструктурування поверхні напівпровідників.