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Resistivity of non-doped and boron-doped magnetron sputtered carbon films

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Electric resistivity of non-doped and boron-doped (2 at. % boron) amorphous carbon (a-C) films deposited by dc magnetron sputtering has been studied as a function of substrate temperature within the range 20 to 650°C. Non-doped a-C films were obtained by sputtering of graphite in argon while boron-doped ones were deposited by sputtering composed (graphite + compound B_4C) target in the same conditions. The film resistivity in two directions, parallel ($\rho_\parallel$) and perpendicular ($\rho_\perp$) to the substrate surface, was measured. The film structure was studied by electron diffraction and Raman spectroscopy. Doping with boron did not change resistivity $\rho_\perp$ at all temperatures investigated, but influenced resistivity $\rho_\parallel$. In the temperature range 20 to 200°C, $\rho_\parallel$ did not change and further dropped sharply, attaining the value observed for non-doped a-C films at T_s~ 400°C. Doping with boron does not change the mechanism of microstructure formation for a-C films but slows down the nucleation process of graphite-like G-phase clusters in amorphous D-phase in the temperature range 20 to 400°C and favors the graphite phase nucleation at T_s>400°C.

Исследовано электросопротивление нелегированных и легированных бором (2 ат. % бора) аморфных углеродных (a-C) пленок, осажденных методом магнетронного распыления на постоянном токе в интервале температур подложки T_s = 20–650°C. Нелегированные a-C пленки получали распылением графита, а легированные бором a-C пленки — распылением составной (графит + соединение B_4C) в аргоне в одних и тех же условиях. Сопротивление a-C пленок измерялось в двух направлениях: параллельно ($\rho_\parallel$) и перпендикулярно ($\rho_\perp$) подложке. Структуру пленок изучали методами электронографии "на отражение" и комбинационного рассеяния света. Легирование бором не повлияло на сопротивление $\rho_\perp$ во всем исследованном интервале температур, но оказало эффект на сопротивление $\rho_\parallel$. В интервале температур 20–200°C $\rho_\parallel$ не изменялось, а затем резко уменьшалось и при T_s~ 400°C достигало величины, наблюдаемой у нелегированных a-C пленок. Легирование бором не изменило, в целом, механизм формирования микроструктуры a-C пленок, но замедлило процесс зарождения кластеров графитоподобной G-фазы в аморфной D-фазе в интервале 20–400°C и способствовало зарождению графитовой фазы при T_s>400°C.

Doped diamond and diamond-like carbon (DLC) films are now considered as promising materials for application in microelectronics. There are several techniques for doping films with such *p*- and *n*-type dopants as boron and nitrogen, respectively. In chemical vapor deposition, a gas containing doping atoms is introduced into gas mixture thus enabling incorporation of doping atoms into growing film [1–4]. Ion implantation with necessary atoms is also used for post-growth doping of films [5–7]. One