Forschungszentrum Karlsruhe
in der Helmholtz-Gemeinschaft

GÜHRING

DIAMOND 2008
19th European Conference on Diamond, Diamond-Like Materials, Carbon Nanotubes, and Nitrides

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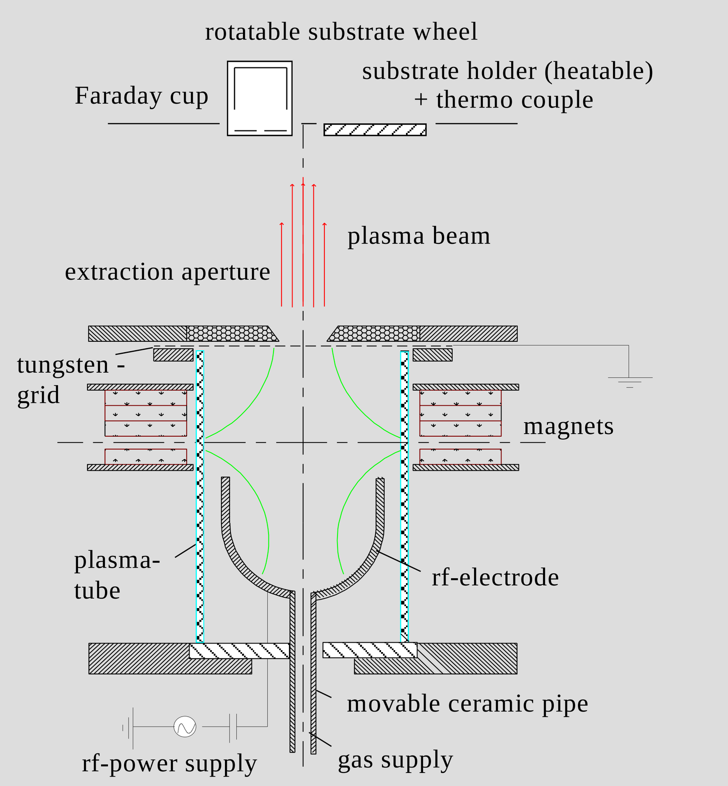
Influence of ion energy, ion flux, flux of film forming particles and surface temperature on the constitution of highly tedrahedral hydrogenated carbon thin films

Experimental setup



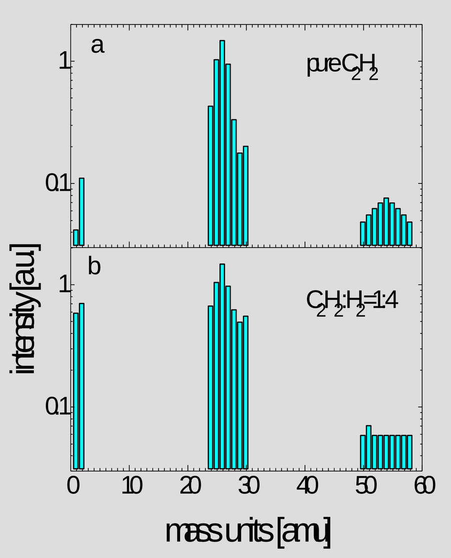
Deposition Parameters

working gas:	C_2H_2
rf-power: (13.56 MHz)	60 W
magnetic field:	200 mT
pressure: (deposition chamber)	$7\cdot10^{-5}$ mbar
ion energies:	140-1000 eV
ion current densities:	0.2mA/cm²
substrate temp.:	30-850°C

quasi neutral plasma beam

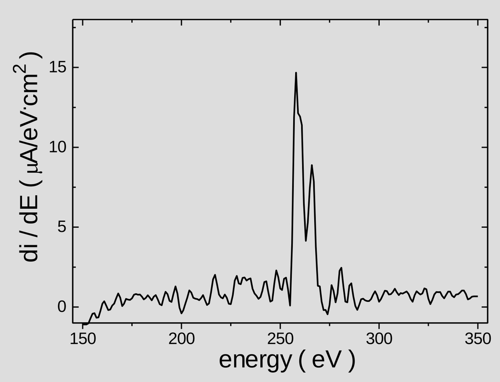
radial homogeneity > 30 mm

Mass spectrum of acetylene at different pressures



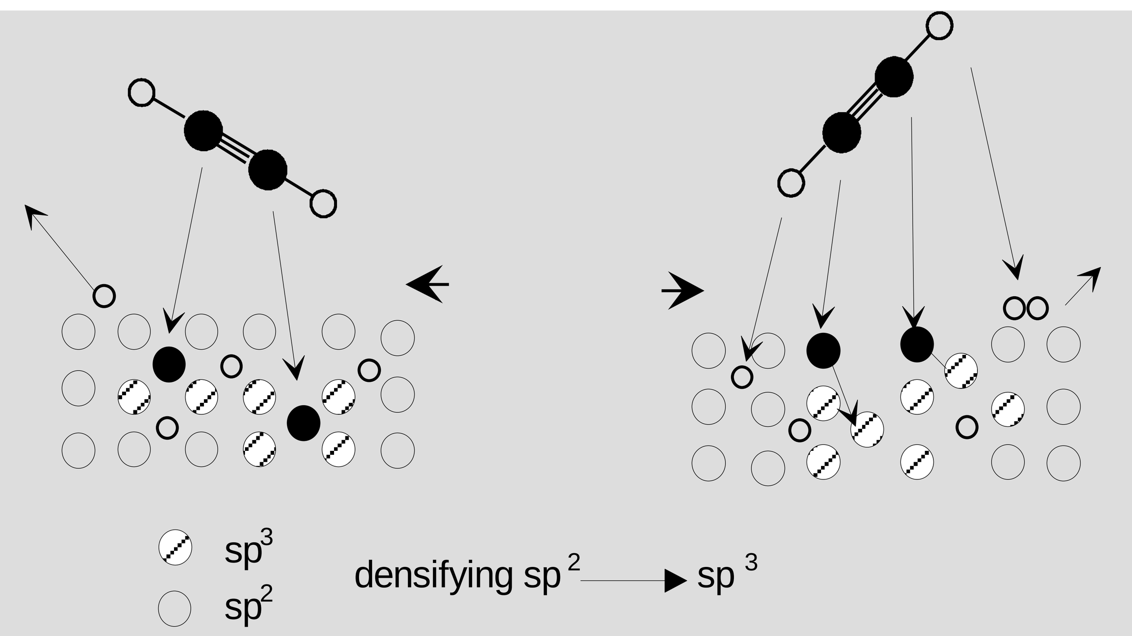
ionization degree > 90 %

Typical ion energy distribution for acetylene



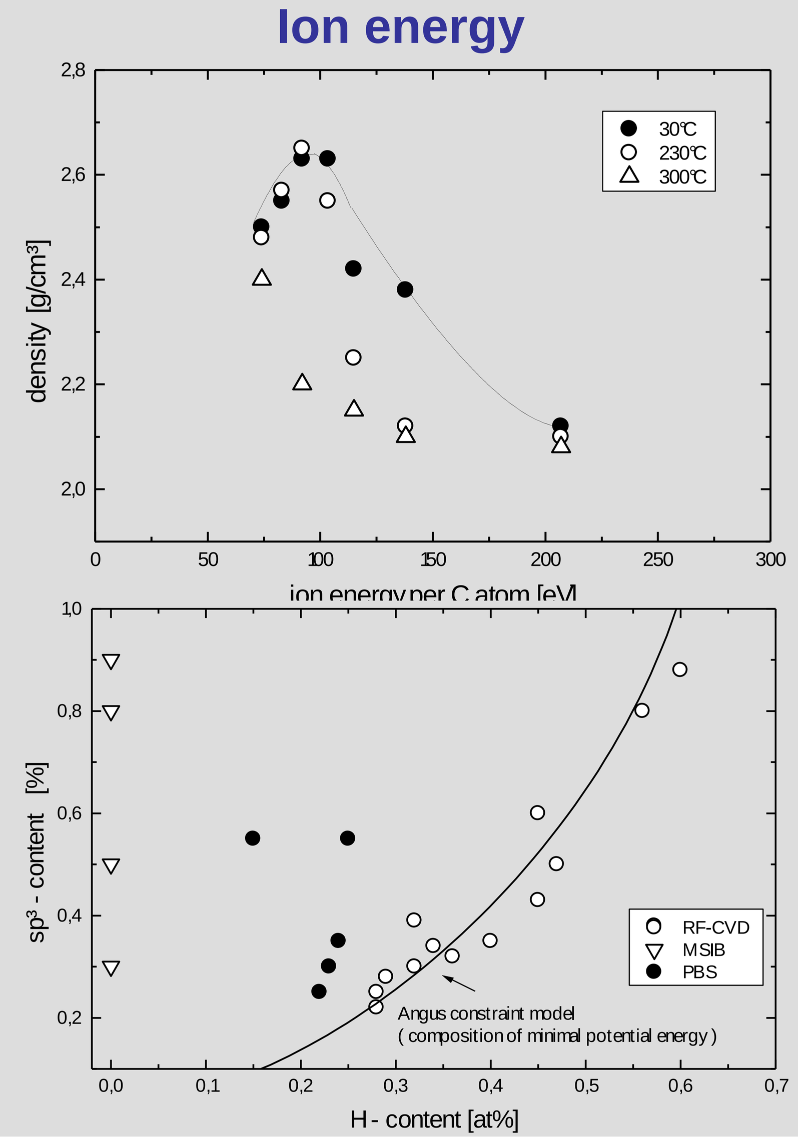
energy resolution ΔE/E≈ 0.1

Particle fluxes & surface processes

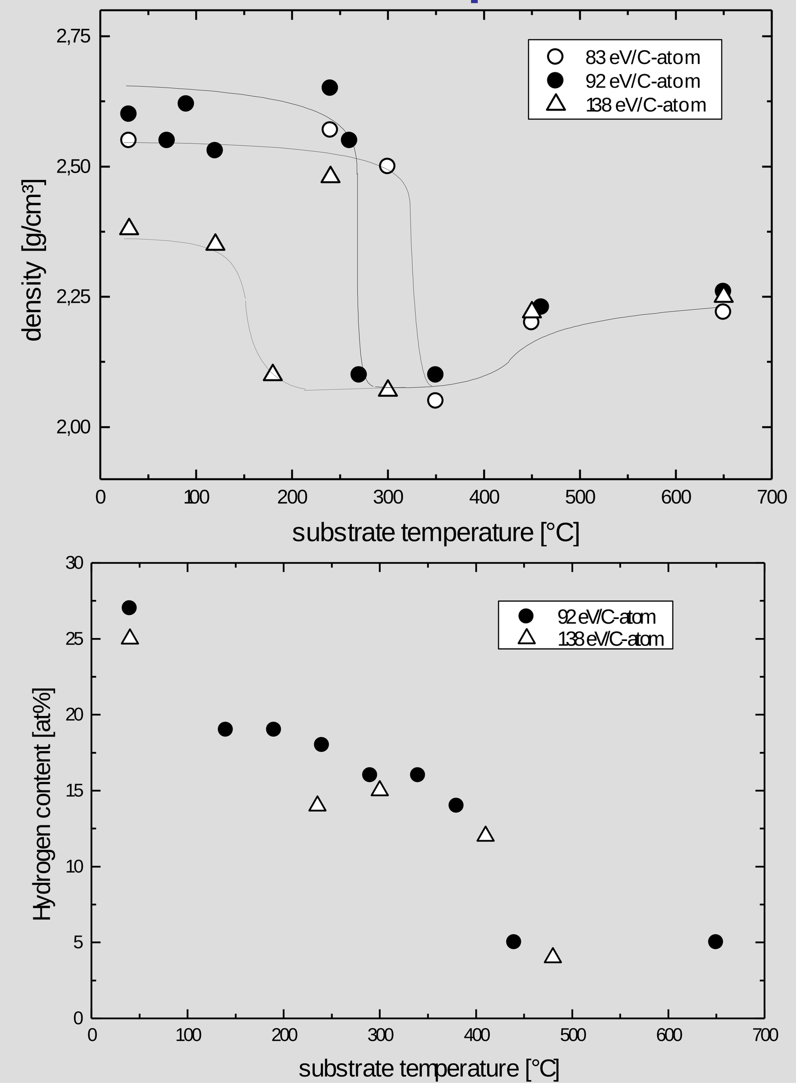


Experimental results

Ion energy



Substrate temperature



Temperature threshold

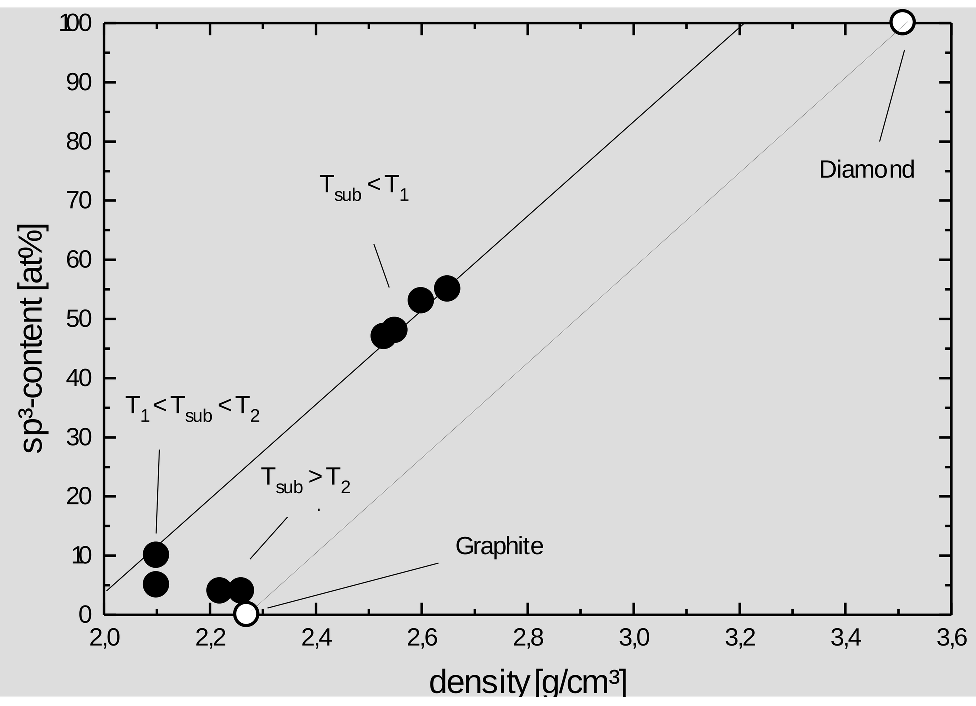
3 different

temperature ranges:

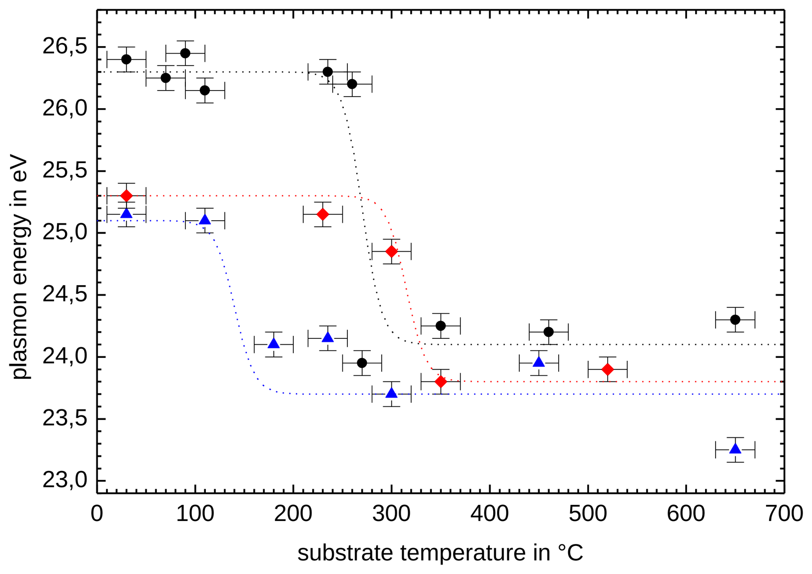
a) $T_{sub} < T_1$

b) $T_1 < T_{sub} < T_2$

c) $T_{sub} > T_2$



Modeling: J. Robertson, Diam. & R. M. 14 (2005) 942

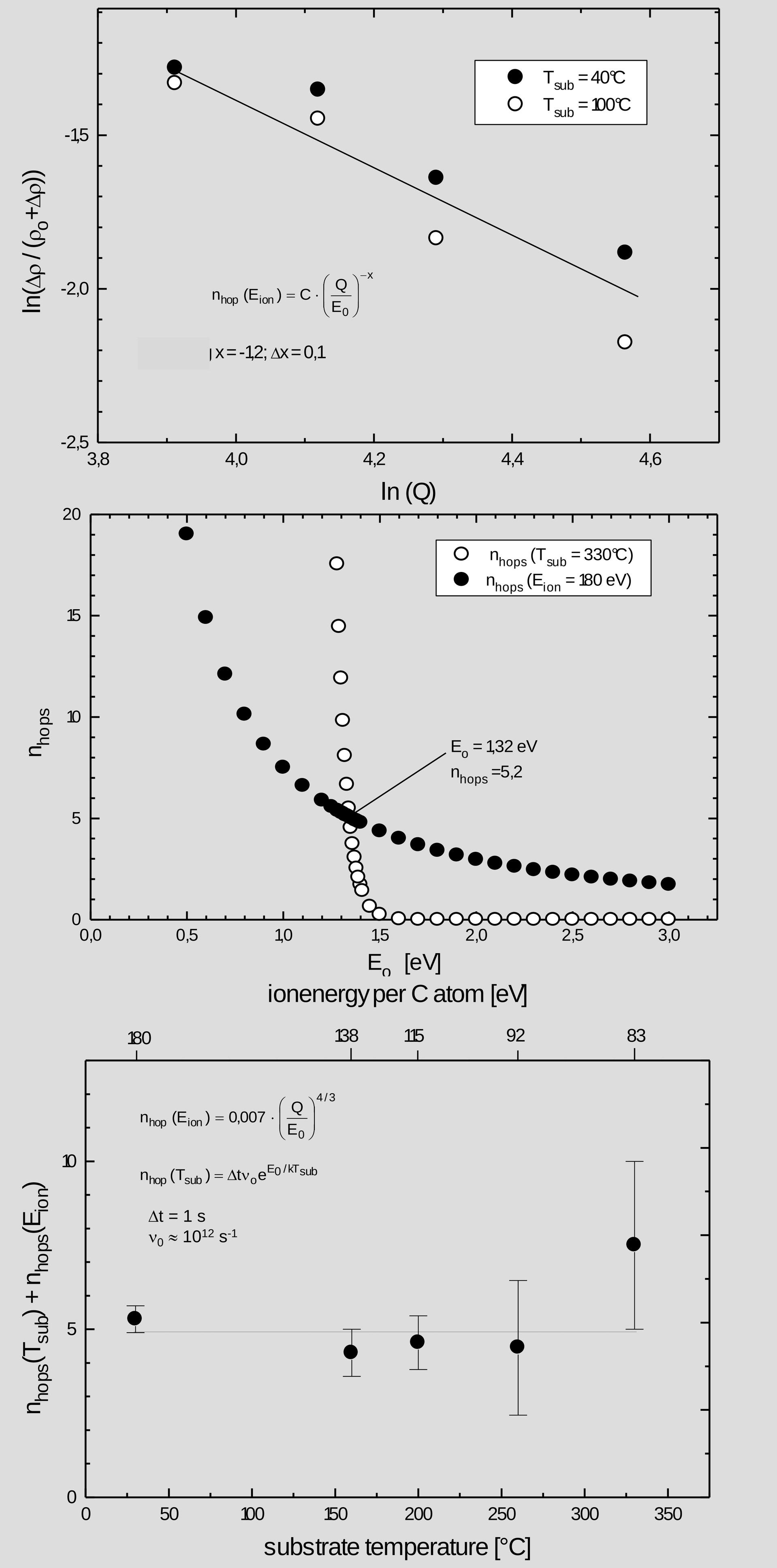


$$\frac{\Delta\rho}{\rho}=\frac{f\phi}{1-f\phi+0.016\left(\frac{E_i}{E_0}\right)^{5/3}}$$

$$\frac{\Delta\rho}{\rho}=\frac{Ff\phi}{F\left(1-f\phi+0.016\left(\frac{E_i}{E_0}\right)^{5/3}\right)+v_0\exp\left(\frac{E_3}{kT}\right)}$$

Modeling: thermal pot

Number of dislocations as a function of E_{ion} for low substrate temperatures



Conclusion

As far as film growth at temperatures below T_2 is concerned, it must be noted that the experimentally observed effect of substrate temperature and ion energy on the relaxation of the film structure can be measured only in the energy range of 90 to 180 eV/C-atom and in the temperature range of 150°C to 330°C.
Energies below 90 eV/C-atom (and above 42 eV/C-atom) primarily contribute to the densification of the structure only. A complete relaxation of the structure of PBS films is supposed to start at temperatures of 330°C in this energy range.
Energies above 180 eV/C-atom cause a nearly complete relaxation even without an increase of the substrate temperature.
At substrate temperatures below 150°C, description of the relaxation process is restricted to the excessive energy introduced by ion implantation ("thermal pot"). This is demonstrated in particular by the data of films deposited at two different temperatures (smaller than 150°C) as a function of ion energy.
At substrate temperatures above T_2, phase conversion processes occur during film growth already. In the special case of PBS films, these processes are attributed to the hydrogen escaping from these films at such temperatures.

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