Effect of Amorphous Carbon Coating on Electron Field Emission from Polysilicon Substrates

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Introduction

Coating of the surface of silicon or poly-, micro-crystalline or amorphous silicon by carbon films deposited at relatively low temperatures can provide effective field emission and is very attractive because of compatibility with associated circuitry fabricated on these substrates.

Experimental

Polysilicon coated wafers were used as substrates. Undoped substrates (denoted as Si1) and substrates doped with phosphorus 4-6 x10^{18}cm^{-3} (denoted Si2) and at 0.8-2 x 10^{20}cm^{-3} (denoted as Si3) were coated by carbon films. These films were grown by Very High Frequency (VHF) CVD, as described in [1], under the following conditions (process C216-5): substrate temperature T_s=225°C, P=56 mTorr, Power = 2 W/cm^2, f= 56 MHz, gas mixture 7% C_6H_{14}+ 93 %H_2, flow Q= 27 sccm. Prior to deposition, the substrates were pretreated in H_2 plasma and bias enhanced nucleation (BEN) was performed. The carbon layer was 700 nm thick. Area is approximately 1 cm^2. Emission was measured in the set-up schematically shown in Fig.1. The UHV chamber, equipped by electron gun and multigrid quasispheric energy analyzer, carousel for 5 samples and a Faraday cup, was used. An energy analyzer was used for AES and EELS characterization. Before and after the measurements, the secondary emission coefficient σ was measured by scanning electron beam, providing 2-D σ-map of sample surface. The current was measured in diode configuration with a 45-55 μm spacing and an anode area of 2x5 mm^2.

Results and discussion.

Emission current-voltage I(V) curves were measured up and down several times from 3 different regions of each sample (by shifting the current collection window over the sample surface). At a few occasions, high voltage breakdown (microarcing) was observed after which this region was excluded from further measurements and analysis. Surface "conditioning" effect (without arcing) was observed in some samples, after which I-V were stable and reproducible. Fig.2 shows I-V curves for different polysilicon substrates coated by the same carbon film in comparison with uncoated ones. The most profound changes in I-V curves with carbon coating were observed in the undoped polysilicon substrate (Si1). The films grown with optimal plasma treatment and deposition conditions demonstrated improved emission properties by reducing the turn-on fields and improving reproducibility of the emission currents.

References:

1. A.I.Kosarev, A.N.Andronov, S.V.Roboresov, T.E.Felter, A.J.Vinogradov, V.V.Zhirnov, M.V.Schutov, "Field emission from amorphous carbon and silicon-carbon films prepared by VHF CVD", *IVMC 1998 Technical Digest*, Asheville, NC, USA, July 19-24, 1998, p. 265-266.

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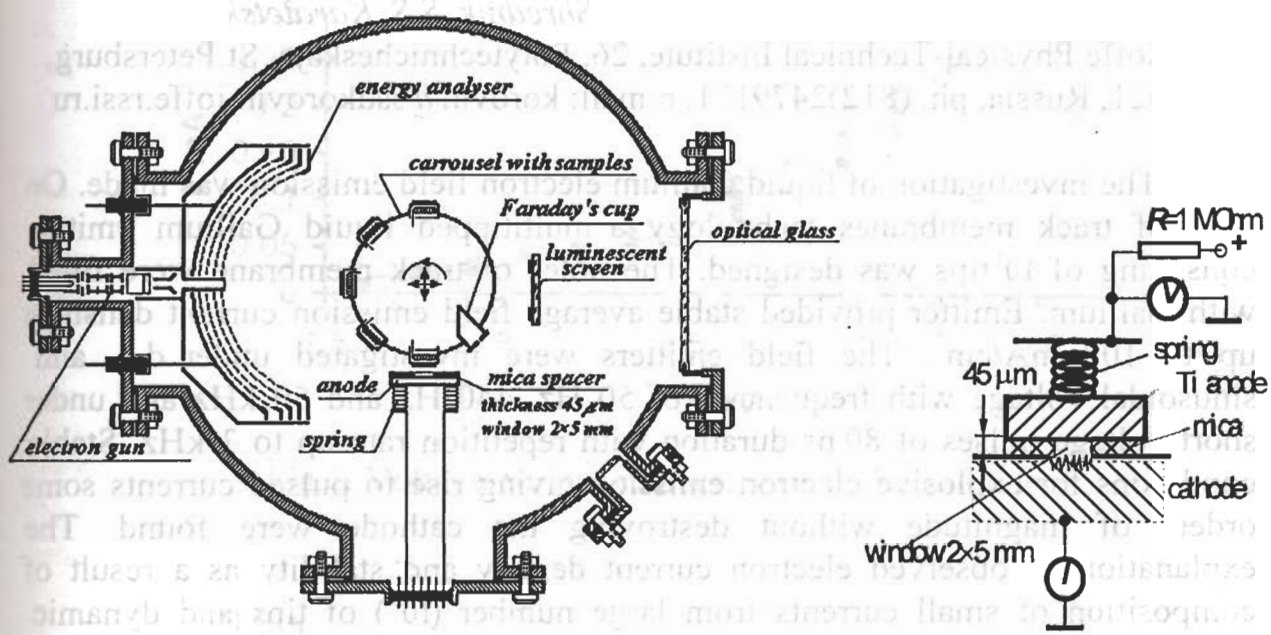
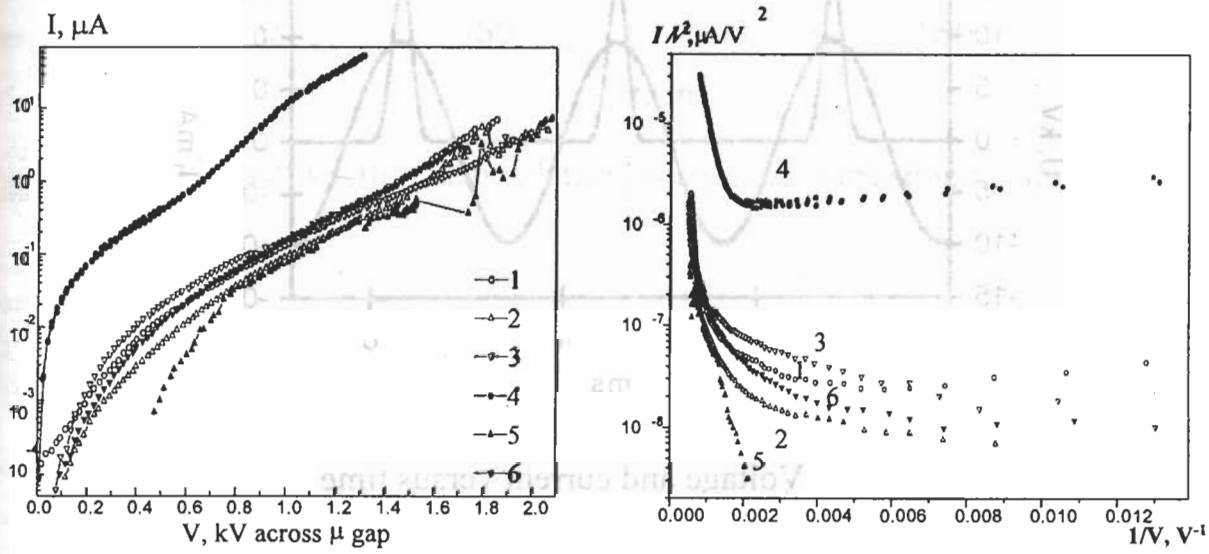


(a) (b)

Fig.1 Diagram of the set-up for emission measurements:
a) UHV chamber for emission measurements and material characterization and
b) schematic of emission current-voltage measurements



(a) (b)

Fig.2. Emission current-voltage curves for different polysilicon substrates in semilog (a) and Fowler-Nordgeim (b) scales.
(1-Si1, 2-Si2, 3-Si3 -without carbon coating; 4-Si1, 5-Si2, 6-Si3 with carbon coating)