control of emitter structures are needed to fully exploit the potential usage of diamond/carbon field emissions. This paper describes a well-engineered molding process for the fabrication of diamond/carbon field emitter cathodes and devices. Practical modifications involving the sp^2 content, doping, and tip sharpening to further enhance diamond/carbon field emission are discussed.

We also report the development of (a) vertical and (b) lateral diamond field emission devices with excellent field emission characteristics. Vertically self-aligned gated diamond vacuum triodes were fabricated from a silicon-on-insulator substrate. This fabrication technique utilizes conventional silicon micro patterning and etching techniques to define the anode, gate, and cathode. The fabrication has achieved diamond field emitter triodes over practical wafer areas. The field emission of the triode array exhibits transistor characteristics with high dc voltage gain, ~800, and transconductance values. A large ac output voltage of ~100 V peak–peak has been achieved. While in the lateral configuration, diamond vacuum diode was fabricated by a novel diamond patterning technique utilizing oxide patterning and lift-off process. Anode–cathode spacings <2 μm were achieved. The fabricated lateral diamond emitter diode exhibits excellent emission characteristics with a low turn-on voltage of ~5 V and a high emission current of 6 μA, from a four diamond "fingers" configuration. The low turn-on voltage (field ~3 V/μm) and high emission characteristics are excellent for reported lateral field emitter structures.

We also present the development of thermal CVD grown carbon nanotubes (CNTs) for cold cathode applications. Preliminary results demonstrate that CNTs configured as diode field emitters exhibit low turn-on fields and high emission current. The emission current produced by the CNTs tested is more than sufficient for flat panel displays in practical use. The CNT-triode devices have also been fabricated. The emission characteristics show gate-controlled modulation of emission current.

Additional field emission behavior of the diamond and carbon derived field emission devices will be presented. The excellent field emission results in the diode and triode configurations suggest the potential usage of diamond/carbon emitters beyond the conventional vacuum microelectronics to encompass usage such as displays and micro-sensors in MEMS applications and beyond.

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Synchrotron X-ray scattering studies of nano-domains in lead containing perovskite relaxor ferroelectrics

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Synchrotron X-ray scattering studies were applied to single crystals of lead magnesium niobate ferroelectric relaxors Pb $(Mg_{2/3}Nb_{1/3})O_3$ (PMN) with several concentrations of Ti doping corresponding to 0, 6, 10, and 30%. PMN has an ABO_3 perovskite structure, where A sites are occupied by Pb atoms, B sites by a mixture of Nb/Mg/Ti. Atoms on the B sites exhibit some degree of ordering that leads to doubling of the unit cell in the direction perpendicular to {1 1 1} type atomic planes. B sites are surrounded by oxygen octahedra. Experimental evidence exists that Pb and O ions are displaced from their ideal atomic positions. These displacements are not completely random and some degree of correlation exists on the short-range scale.

Synchrotron X-ray scattering techniques were applied to study chemical and displacement ordering from the coherently scattering nanoregions producing two kinds of superlattice reflections called (a) F spots; (b) α spots in literature. These reflections are direct result of doubling of the unit cell in the directions perpendicular to {1 1 1} and {1 1 0} atomic planes, respectively. F and α superlattice reflections were detected only in 0 and 6% Ti doped PMN (PMN–6%PT) single crystals. Radius of correlations in the nanodomains producing F spots is limited to 50 Å and independent of temperature in the 10–800 K interval. Main contribution to the structure factor of the F spots is from chemical ordering on the B sites. However, it was found that correlated displacements contribute to the structure factor of the F spots as well. Existence of the strong asymmetric tails in F spots was detected only in <1 1 1>* reciprocal direction, which suggests existence of the strong distortions in the direction perpendicular to {1 1 1} planes caused by the atomic size effect and/or atomic displacements. Anomalous scattering on the F spots near Pb L_{III} absorption edge provides further evidence that Pb displacements in <1 1 1> direction are correlated on the short-range scale, although the effect on the structure factor was found to be very weak after correcting raw data for known experimental errors and X-ray absorption.

Temperature dependent studies in the range of 10–800 K have shown that the main origin of the α spots in PMN and PMN–6%PT can be attributed to the correlated atomic displacements in {1 1 0} planes. Their integrated intensity exhibits strong temperature dependence below Vogel–Fulcher freezing temperatures T_f, which coincides with the temperature of collapse of the stable remanent polarization. Correlation radius of 30 Å, obtained from the width of these reflections, is independent of chemical composition and temperature below T_f.

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