Synchrotron Studies of Antiferroelectric and Intermediate Liquid Crystal Phases

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Abstract

This thesis presents an investigation of the structural properties and the stability of the 3-layer and 4-layer intermediate phases, as well as the mechanisms of switching in the antiferroelectric and intermediate phases under the application of electric fields, in antiferroelectric liquid crystal materials. The samples were studied using small-angle X-ray scattering (SAXS) and resonant X-ray scattering techniques carried out at synchrotron facilities. Further experiments were conducted using electro-optic techniques.

Resonant X-ray scattering was used to reveal for the first time the structure of the 3-layer intermediate phase and the dependency of the structure's properties on temperature and material. The experiments also revealed further properties of the previously-confirmed 4-layer intermediate phase structure.

The thesis reports remarkably wide intermediate phases of up to ~30°C that have been observed via resonant X-ray scattering and polarized microscopy in mixtures of antiferroelectric liquid crystals with highly chiral dopants. Various experimental methods including SAXS and electro-optic techniques were further employed in order to determine a set of physical parameters for the mixtures, such as the smectic layer spacing, tilt angle and spontaneous polarization. The results were used to show that the conformational packing of the molecules is a major factor affecting the stability of the intermediate phases.

Time-resolved SAXS was used to study the electric-field induced motion of the smectic layers in the intermediate and antiferroelectric phases on switching between the field-induced ferroelectric states in device geometries. Reversible layer motion was observed to occur within timescales comparable to the materials' electro-optic response times (~100μs). The switching mechanism involves changes in the organisation of smectic layers in the depth and plane of the device. Moreover, the results show that the mechanism is associated with a change in the smectic layer spacing, and this was the first time such an effect has been observed during switching.

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