Thin nano-crystalline self-supported ceramic films: preparation, properties and applications.

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Abstract

An overview of the current state of the art on self-supported nano-crystalline ceramic films, their preparation and properties is given. Three major effects identified as the ones that strongly affect behavior of self-supported nanocrystalline structures are considered in detail: intergrain strain, chemically induced stress and self-organization of elastic domains. Intergrain strain appears as a result of uncorrelated changes of lateral dimensions in adjoining grains. Induced either by phase transformation or by anisotropic thermal expansion, intergrain strain in nanocrystalline films is strong enough to alter phase equilibrium, leading to a variety of mechanical anomalies. Chemically induced strain is known to cause macroscopic stress and spontaneous deformation in bulk ion conductive ceramics due to a strong link between the crystal unit cell dimensions and chemical composition. This effect combined with intergrain strain represents a significant challenge for preparation of nanocrystalline self-supported structures, because it may cause rapid phase transformations triggered by substrate removal. Self-organization of elastic domains may occur in materials capable of forming dynamic adjustable textures, such as ferroelectric or ferroelastic thin films. Elasticity of polydomain self-supported nanocrystalline structures is significantly different from that of bulk ferroelectric ceramics. Hence, buckling of self-supported nanocrystalline structures may provoke spontaneous self-organization of elastic domains, resulting in formation of regions with complete spontaneous domain alignment and regions without domain alignment at all. This effect is similar to a spinodal decomposition and the self-supported structures containing such ordered-disordered regions possess a number of unusual electrical and mechanical properties. The rapid accumulation of knowledge about the chemical and mechanical properties of self-supported nanocrystalline structures promises their successful application in a large variety of devices, ranging from microscopic fuel cells to various detectors and microwave devices.