

# Low-temperature crystallization of high-dielectric (Ba,Sr)TiO<sub>3</sub> thin films for embedded capacitors

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## Abstract

(Ba,Sr)TiO<sub>3</sub> (BST) thin film with a perovskite structure has potential for the practical application in various functional devices such as nonvolatile-memory components, capacitor, gate insulator of thin-film transistors, and electro-optic devices for display. Normally, the BST thin films derived from sol-gel and sputtering are amorphous or partially crystalline when processed below 600°C. For the purpose of integrating BST thin film directly into a Si-based read-out integrated circuit (ROIC), it is necessary to process the BST film below 400°C

The microstructural and electrical properties of low-temperature crystallized BST film were studied. The BST thin films have been fabricated at 350°C by UV-assisted rapidly thermal annealing (RTA). The BST films are in a single perovskite phase and have well-defined electrical properties such as high dielectric constant, low dielectric loss, low leakage current density, and high breakdown voltage. Photoexcitation of the organics contained in the sol-gel-derived films by high-intensity UV irradiation facilitates elimination of the organics and formation of the single-crystalline phase films at low temperatures.

The amorphous BST thin film was transformed to a highly (*h00*)-oriented perovskite structure by high oxygen pressure processing (HOPP) at as low as 350°C. The dielectric properties of BST film were comparable to (or even better than) those of the conventionally processed BST films prepared by sputtering or post-annealing at temperature above 600°C. When external pressure was applied to the well-known contractive BST system during annealing, the nucleation energy barrier was reduced; correspondingly, the crystallization temperature decreased.

The UV-assisted RTA and HOPP, as compatible with existing MOS technology, let the BST films be integrated into radio-frequency circuit and mixed-signal integrated circuit below the critical temperature of 400°C.