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(19) **United States**(12) **Patent Application Publication****Ramamoorthy et al.**(10) **Pub. No.: US 2023/0231055 A1**(43) **Pub. Date: Jul. 20, 2023**(54) **MANGANESE-DOPED PEROVSKITE  
LAYERS AND SEMICONDUCTOR DEVICE  
INCORPORATING SAME***H01L 29/737* (2006.01)*H01L 29/66* (2006.01)*H01L 29/74* (2006.01)*H10B 53/30* (2006.01)(71) Applicant: **Kepler Computing Inc.**, San Francisco,  
CA (US)(52) **U.S. Cl.**CPC .... *H01L 29/78618* (2013.01); *H01L 29/2003*(2013.01); *H01L 29/7375* (2013.01); *H01L**28/57* (2013.01); *H01L 29/6684* (2013.01);*H01L 29/7869* (2013.01); *H01L 29/7408*(2013.01); *H01L 28/65* (2013.01); *H01L 28/56*(2013.01); *H10B 53/30* (2023.02); *H10B**12/36* (2023.02)(72) Inventors: **Ramesh Ramamoorthy**, Moraga, CA  
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Santa Clara, CA (US)(21) Appl. No.: **18/181,426**(22) Filed: **Mar. 9, 2023****Related U.S. Application Data**(60) Continuation of application No. 17/819,601, filed on  
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11,164,976.(60) Provisional application No. 62/831,044, filed on Apr.  
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(57)

**ABSTRACT**

The disclosed technology generally relates to ferroelectric materials and semiconductor devices, and more particularly to semiconductor memory devices incorporating doped polar materials. In one aspect, a semiconductor device comprises a capacitor which in turn comprises a polar layer comprising a base polar material doped with a dopant. The base polar material includes one or more metal elements and one or both of oxygen or nitrogen. The dopant comprises a metal element that is different from the one or more metal elements and is present at a concentration such that a ferroelectric switching voltage of the capacitor is different from that of the capacitor having the base polar material without being doped with the dopant by more than about 100 mV. The capacitor stack additionally comprises first and second crystalline conductive oxide electrodes on opposing sides of the polar layer. The capacitor stack further comprises first and second barrier metal layers on respective ones of the first and second crystalline conductive oxide electrodes on opposing sides of the polar layer.

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