Growth and dielectric properties of Nb_2O_5 single crystal by the optical floating zone method

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The development of the microelectronics requires the high dielectric permittivity (high-κ) materials to replace the conventional dielectrics employed for smaller components with enhanced performance [1]. Nb_2O_5 with H-type structure, a stable form at high temperature and pressure, has been reported that exhibit high dielectric permittivity compared to other oxide materials, which has been considered as a capacitor material for the next generation of memory devices and widely investigated [2].

Large size and high quality Nb_2O_5 single crystal was successfully grown by optical floating zone method under air atmosphere [3-4]. The size of the grown crystal was typically about 6-7 mm in diameter and 60-70 mm in length. Based on the observation of the effect of the growth parameters on the growth of crystal, the crystal growth parameters were optimized. The crystal structure and prefer orientation have been characterized by means of X-ray diffraction (XRD). X-ray single crystal diffraction and X-ray rocking curve indicate the material is a single crystal with high quality. The relative permittivity and loss tangent along growth and [001] direction were investigated in the temperature range between 20 °C and 200 °C. At a frequency of 1 MHz and 20 °C, the dielectric permittivity along the growth direction and [001] direction are 42 and 48, respectively. The stabilization of H-type structure (H-Nb_2O_5) exhibits the large dielectric permittivity. It is expected that Nb_2O_5 single crystal is a very promising material for dielectrics and application in microelectronics devices.

References

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