Development of a MKID camera with high-quality Al films for millimeter-wave astronomy

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***Abstract*— We have been developing millimeter and sub-millimeter wave cameras with microwave kinetic inductance detectors (MKID) and silicon lens arrays. MKID consists of a coplanar waveguide to be easily coupled to a double slot antenna. MKID is patterned on a high-quality aluminum film which has been developed by a molecular beam epitaxy method (MBE). The millimeter-wave camera has sensitivity at the frequency from 200 to 240 GHz, whose bandwidth is restricted by the impedance properties of the double slot antenna. The antenna properties have been simulated with 3D EM simulator (CST). The radius of the silicon lens is 2.05 mm, and the geometry of the lens is determined so that beam patterns from the lens become symmetrical and main lobe levels become -10 dB at around 20 degrees. The lens array is shaped with a direct machining technique.**

To investigate the effect of the quality of superconducting films on MKID, the properties of MKID are compared between an MBE-Al film and an aluminum film deposited with electron beam evaporation (EB) with thickness of 150 nm. Although the residual resistivity ration of the MBE film is twice higher than that of the EB film, the quasiparticle lifetime, noise level, and responsivity of the both MKID are comparable. In consequence, the electrical NEP of the both films are indistinguishable. The quasiparticle lifetime is 450 μs at 0.1 K and shorter than the lifetime reported in Baselmans et al., therefore the performance of the both MKID could be limited by stray light. A measurement set-up is under reconstruction to reduce unexpected radiation which enters the detectors.

Noise equivalent power (NEP) and optical efficiencies of the MKID camera with the high-quality aluminum films have been evaluated with a 0.1 K refrigerator. In a dark circumstance, the electrical NEP of the MKID is around 6*10-18 W/Hz. Under 8 K blackbody radiation, the optical NEP and the optical efficiency of the camera including the lens are evaluated to be 7 *10-15 W/Hz and around 15 %, respectively, at the sample-bath temperature of 0.1 K.