**Supplementary Material**

# Title: Two-Step Growth of High Quality Nb/(Bi0.5Sb0.5)2Te3/Nb Heterostructures for Topological Josephson Junctions

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1. **(Bi0.5Sb0.5)2Te3 deposition on various substrates**


FIG. S1 (a) RHEED pattern of (Bi0.5Sb0.5)2Te3 grown on SrTiO3(111) substrates. (b) RHEED intensity oscillation of(Bi0.5Sb0.5)2Te3films on SrTiO3(111), Al2O3(0001) and H-passivated Si(111)surface, respectively.

1. **(Bi0.5Sb0.5)2Te3 film directly on Nb surfaces**


FIG. S2 (a) XPS results of the Bi 4f peak (left) and Te 3d (right) peak of the poor film deposition at the temperature 280°C. (b) RHEED pattern of the film at the deposition temperature 280°C.

1. **RHEED pattern monitoring of (Bi0.5Sb0.5)2Te3 on H-passivated Si(111)**


FIG. S3 (a) Line profile of RHEED streak of (Bi0.5Sb0.5)2Te3 thin films on H-passivated Si(111)surface. From top to bottom: Substrate, 1QL deposition to 5 QL deposition. (b) RHEED intensity oscillation (red line) and the peak width of RHEED streak (blue line) on the (Bi0.5Sb0.5)2Te3 thin films on H-passivated Si(111)surface.