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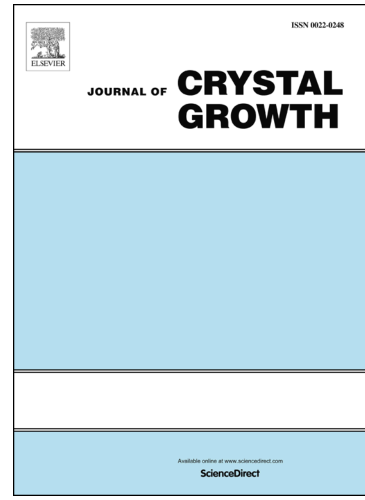

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ACCEPTED MANUSCRIPT

Stencil lithography of superconducting contacts on MBE-grown topological insulator thin films

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Abstract
Topological insulator $(Bi_{0.06}Sb_{0.94})_2Te_3$ thin films grown by molecular beam epitaxy have been capped in-situ with a 2 nm Al film to conserve the pristine topological surface states. Subsequently, a shadow mask - structured by means of focus ion beam - was in-situ placed underneath the sample to deposit a thick layer of Al on well-defined microscopically small areas. The 2 nm thin Al layer fully oxidizes after exposure to air and in this way protects the TI surface from degradation. The thick Al layer remains metallic underneath a 3-4 nm thick native oxide layer and therefore serves as (super-) conducting contacts. Superconductor-Topological Insulator-Superconductor junctions with lateral dimensions in the nm range have then been fabricated via an alternative stencil lithography technique. Despite the in-situ deposition, transport measurements and transmission electron microscope analysis indicate a low transparency, due to an intermixed region at the interface between topological insulator thin film and metallic Al.

1 Keywords
B2. Topological insulator, B2. Superconductor, B3. Josephson junction, A3. Molecular beam epitaxy, A1. Shadow mask, A1. Stencil lithography

2 Introduction
Three-dimensional (3D) topological insulators (TIs) possess an insulating bulk and metallic surface states with their spin locked to the momentum [1,2]. In proximity to an s-wave superconductor (SC), quasi-particle excitations – so called Majorana zero modes (MZMs) – are predicted to occur at the surface of TIs [3]. Due to their non-abelian exchange statistics, such MZMs are expected to enable fault-tolerant quantum computation [4,5]. While the final proof for their existence is still elusive, first signatures of Majorana Modes have been found in 3D and 2D HgTe topological insulator thin films [6,7]. HgTe is known for its very distinctive surface transport and low bulk carrier contribution [8]. However, its small bandgap of about 10 meV makes any application based on the topological surface states impossible for room temperature devices. In contrast, $(Bi_{0.06}Sb_{0.94})_2Te_3$ TI thin films have a sufficiently large bandgap of about 200 meV [9]. Unfortunately Bi-Sb based topological insulator thin films suffer from high bulk carrier contributions, which make the observation of surface transport in magnetoelectric measurements

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