Charge Tunable ErAs Islands for Backgate Isolation in AlGaAs Heterostructures

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Abstract. Self assembled ErAs islands on GaAs embedded between a backgate electrode and a two-dimensional electron gas were grown by molecular beam epitaxy. The nanometer sized islands form Schottky contacts, leading to a potential barrier from overlapping depletion regions which insulate the backgate from the 2DEG. From temperature dependant measurements and charging experiments the barrier height between the islands and onto the islands could be determined. In addition the effects of illumination by an LED were studied

Two-dimensional electron gases (2DEGs) based on the Ga[Al]As system are the starting point for a wide range of research. In addition to the option of applying topgates, backgates (BGs) can be a desirable asset. Most traditional approaches for insulating the 2DEG from the BG rely on a GaAs spacer layer grown at low temperatures (LT GaAs) [1,2]. Here we present an alternative approach based on layers of ErAs islands that form Schottky contacts with overlapping depletion regions. As it turned out this system showed interesting effects in its own right.

The samples under study were grown by molecular beam epitaxy. A schematic diagram of the layer sequence and the conduction band profile [3] are shown in Fig.1. The 2DEG is located 34nm below the surface at an AlGaAs/GaAs interface, separated from the metallic backgate (Si doped GaAs) by 1.3□m. Sandwiched inbetween are 20 Er layers spaced by 25nm. As has been previously reported [4,5] Er spontaneously forms ErAs islands under these conditions, similar to self assembled quantum dots. The morphology of the islands depends on the growth parameters: thicker Er layers result in higher island densities whereas higher growth temperatures yield larger islands [5]. In our wafer sequences of 1.5ML of Er were deposited at yxK corresponding to an island size of roughly xynm according to [5]. High quality crystal overgrowth has been reported for Er layers below 3ML owing to the possibility of seeding between the islands [6]. All measurements discussed below were done on standard Hall bar geometries with separate Ohmic contacts for the 2DEG and backgate. Later a Ti/Au topgate covering the mesa was added.