Surface passivation effect in $(NH_4)_2S_X$-treated GaAs probed by laser-combined scanning tunneling microscopy

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Shaken-pulse-pair-excited scanning tunneling microscopy (SPPX-STM) was applied to probe the surface passivation effect in GaAs treated with $(NH_4)_2S_X$ solution ($1<x<3$), since the time-resolved tunneling current ΔI in SPPX-STM reflects the lifetime of photoexcited carriers through surface photovoltage (SPV) affected by such phenomena as the recombination and trapping in deep states [1,2]. As compared with the usual chemical etching, the $(NH_4)_2S_X$-treatment brings about an increase in the photoluminescence (PL) intensity, metal-dependent Schottky barrier heights and improved characteristics of metal-insulator-semiconductor (MIS) structures, indicating the reduction of a large surface recombination velocity (SRV) and/or a high surface state density at the GaAs surface [3]. The carrier density decays underneath the STM tip was conducted from a decay time τ of ΔI curve as a function of delay time between two pulses in the nanosecond range. Two decay components of τ_1= 3.6 ns and τ_2= 128 ns were obtained for the chemical etching, while those of τ_1 = 30 ns and τ_2= 204 ns for the $(NH_4)_2S_X$-treatment. This difference in decay time between two samples was caused by the surface treatment on the same substrate, and both τ_1 and τ_2 lengthened after the $(NH_4)_2S_X$-treatment. Based on these results, the relaxation of SPV involving the surface recombination process is discussed. Also the dependence of decay time on the carrier concentration ranging from 10^{15} cm^{-3} to 10^{18} cm^{-3} is presented.

References

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