Enhancing light-emission efficiency from Si-MOS tunneling diodes by KOH wet etching

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Abstract – *It is confirmed that the efficient light emits at the Si bandgap energy in the MOS tunneling diode structure. But its external quantum efficiency only about ~10^{-5} . We make the surface roughness in the Anisotropic Dissolution of Si(100) in Aqueous KOH. Such surface roughness enhance phonon-assisted radiative recombination. By KOH etching, the external quantum efficiency arrived at ~10^{-4}.*

Introduction

Here we report that by use of SiO_2 nanoparticles in the oxide layer in metal-oxide-silicon (MOS) structure and anisotropic wet etching solution KOH to improve the surface quality, the external quantum efficiency of electroluminescence (EL) at the Si bandgap energy could be enhanced to $1.5x10^{-4}$.

Experiment data demonstration

The processing steps were as follows: First the native oxide upon the silicon wafer was removed. We use KOH solution to improve the surface quality of silicon. Then the solution with SiO_2 nanoparticles was spun onto the wafer and dried in an oven. Nanoparticles are with a feature size of 8~11 nm. The thickness of this nanoparticle layer is about 150 m. A thick layer of Al was evaporated onto the backside of the silicon wafer to form the electrical contact. Finally, the Ag paint was directly applied on top of the nanoparticles to hold a Au wire for another electrical contact. A schematic of the device is shown in Fig.1. Fig.1 also shows a scanning-electron microscope photo of the cross-sectional view of the device.

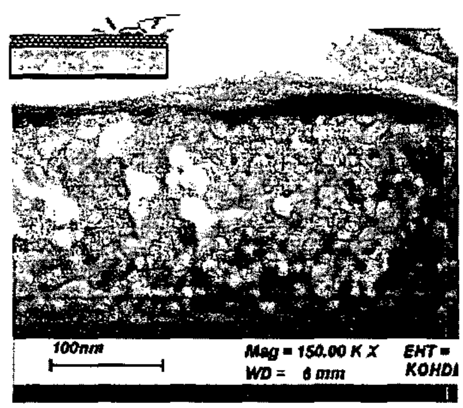

Fig. 1 Schematic of MOS tunneling diode with nanoparticles and SEM photo of cross-sectional view.

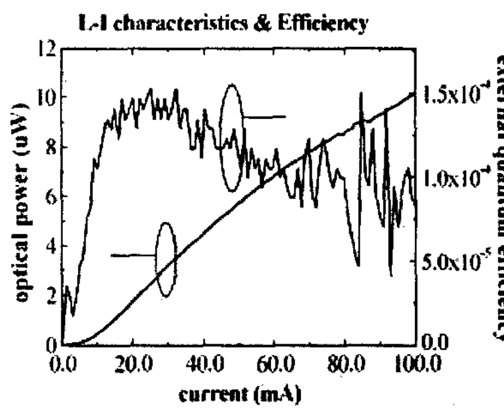

Fig. 2 Output power & external quantum efficiency vs. injection current

Fig. 2 shows the performance of this device. The EL external quantum efficiency rapidly increases and reaches $1.5x10^{-4}$ for operation current between 20 to 30 mA, then slightly drops to 10^{-4} due to the thermal effect. The EL power could be 10 μW at the injection current of 100 mA(current density 12.7 A/cm^2). The power is measured only from the periphery of the Ag paint pad. Because this pad could obstruct a portion of light generated from the devices, the actual light power might be more than 10 μW. If the total EL power is included, the EL quantum efficiency probably exceeds 10^{-3}.

Conclusions

We have demonstrated that the use of SiO_2 nanoparticles and KOH wet etching could make the highly efficient Si-MOS tunneling diode. The possibility of efficient EL from MOS tunneling diodes gives the great promise of optical interconnect among ULSI chiops based fully on the CMOS technology.

0-7803-7766-4/03/$17.00 ©2003 IEEE