OPTOELECTRONICS AND ADVANCED MATERIALS – RAPID COMMUNICATIONS Vol. 2, No. 12, December 2008, p. 818 - 821

Low resistance nonalloyed In ohmic contacts to n-Si irradiated by Nd: YAG laser pulses

R. A. ISMAIL*, K. A. HUBEATIR[a], N. H. KALIF[a]
School of Applied Sciences/ University of Technology-Iraq
[a]*Department of Laser Engineering/ University of Technology-Iraq*

In the present work, the feasibility of formation near-ideal ohmic contact of In/n-Si by 300 μs duration Nd:YAG pulsed laser processing has been demonstrated. Several laser pulses energy densities have been used. Topography of the irradiated region with different conditions was extensively discussed to support other measurements to evaluate the ohmic contact quality. I-V characteristics in the forward and reverse bias and barrier height measurements have been studied for different irradiated samples to determine the laser energy density that gives best ohmic behavior. Comparing the current results with published results, it is found that these results are competitive and meet the standards of good ohmic contact, specific contact resistance of 1.9 x 10^{-4} Ω.cm^2 has been obtained at 21.1 J.cm^{-2} laser energy density, which is the lowest value ever reported for In/n-Si.

(Received October 13, 2008; accepted November 27, 2008)

Keywords: n-Si, YAG:Nd laser, Ohmic contact, Indium, I-V characteristics

1. Introduction

Ohmic contact with low specific resistance is a major standing problem that should be taken in consideration in the design and fabrication of electronic devices, such as bipolar transistors, light emitted diodes, solar cells [1-4] etc.

Interface states between metal and semiconductor arise from dangling bonds at the interface. When a metal is deposited on semiconductor, interface states pin the interface Fermi level, making the Schottky barrier height independent of the metal work function. Ohmic contacts have been conventionally prepared by decreasing the width of the Schottky barrier so that, electrons can tunnel through it. Many approaches have been reported to obtaining good ohmic contact such as: (1) high-electron concentration under the ohmic contact that can be achieved by conventional doping techniques (diffusion or ion implantation) [5], (2) employing multilayer metallization in which one of the metals deposited is an acceptor impurity and the other metals are donors [6], (3) electrolytical metal tracer technique (known as ELYMAT) [7], and (4) passivation of semiconductor surface to obtain interface states that have a negative Schottky barrier [8].

Laser has been used widely in making ohmic contacts onto semiconducting materials especially Si (n, p). In this study, ohmic contacts by long pulse Nd:YAG laser was produced on Si without using dopant diffusion. Characteristics of ohmic contacts were characterized.

2. Experimental details

n-type monocrystalline Si wafer of (111) orientation and 3-5 Ω.cm resistivity was irradiated by Nd:YAG laser pulse (1.064 μm wavelength and 300 μs duration) after degreasing and oxide removing of the treated region using HF acid. The irradiation was achieved under different laser energy densities (see Table 1).

Table 1. Irradiation parameters.

Energy density (J.cm^{-2})	5.92	11.34	16.8	18.4	21.1
Effective Spot Area (cm^2)	0.038	0.0167	0.0044	0.0038	0.0032

Topography of the treated region was studied with aid of optical microscope. Indium film with thickness of 500nm of 5N purity was deposited onto treated region using thermal resistive technique under pressure down 10^{-6} Torr. The evaporation achieved through special mask, and ohmic behavior of this contact was extensively evaluated.

3. Results and discussion

The topography of Nd:YAG treated region is illustrated in the photographs of Fig. 1 (a), (b) and (c). Fig. 1 (a) shows a formation of crack with definite angles (60, 120) for laser energy densities (E_d) up to 11.34 J/cm^2, these cracks are certainly formed due to thermal shocks. At 16.8 J/cm^2 of laser density, dislocations are produced as shown in fig. (1-b) that mainly due to high cooling rate (quenching) of the hot surface, while protuberances, ripples, and concentric waves are occurred at laser densities greater than 16.8 J/cm^2 as introduced in Fig. 1 (c) that are probably elucidated by the interaction between