Interest Of A Short Plasma Treatment To Achieve High Quality Si-SiO_2-Si Bonded Structures

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For many years direct wafer bonding has been used in various fields of applications[1, 2] In most of SiO_2/SiO_2, SiO_2/Si or Si/Si hydrophilic bonded structures and in case of wet chemical cleaning before bonding [1-3], it had been highlighted that a moderate bonding energy was only reachable if the thermal treatments were kept below about 700°C [3]. Recently new bonding processes based on plasma surface treatments before bonding have been developed to induce strong bonding at low temperature (<400°C) [4,5]. One of the main problems generally occuring is that many defects (e.g. voids) appear when using low temperature treatment, for instance in the [200°C-500°C] range. In this paper, we will focus on energy and quality enhancement due to O_2 plasma use.

Experiments have been then carried on mainly using oxygen plasma RIE with 100mm bare and/or thermally oxidised silicon wafers. Before using RIE plasma process, standard wet chemical cleaning were used leading to hydrophilic surface wafers. These wafers were bonded two by two to evaluate SiO_2/SiO_2 or SiO_2/Si bonding energies and qualities in the [200°C-500°C] temperature range. Following plasma treatment, wafers were either directly bonded or water dipped before bonding. After 200°C annealing, it can be put in evidence that bonding energies are slightly drop down using a water dipping, but bonding of a higher quality are achieved. No void was detected either by IR observations or by acoustic microscopy.

In that way plasma parameters (RF power, pressure, process time…) were varied. For instance, it is worth noting that a maximum of bonding energies can be pointed out around 30s, while the RF power is ~250W and the oxygen pressure is ~50mT (Fig. 1). In this case, bonded structures are annealed at 200°C before energy measurements.

Investigations on mechanism which leads to bonding energy enhancement by plasma process can be partially conducted through oxygen sputtering and implantation mechanisms. For instance, surface roughness evolutions versus plasma parameters were investigated before bonding through AFM measurements. For instance, effects of [15s to 90s] plasma treatments were analysed (Fig. 2). If such plasma mechanisms would deserve to be better understood, it is worth noting that high energy bonding of high quality are routinely achieved.

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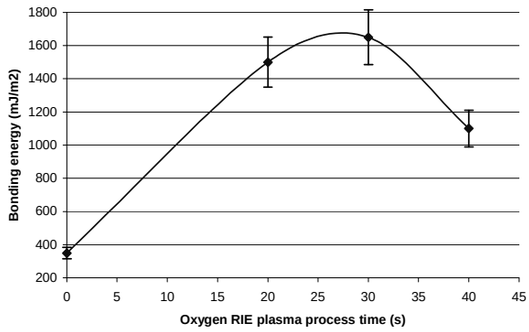

Figure 1 : Bonding energies versus O_2 RIE plasma time for structures annealed at 200°C, 2h.

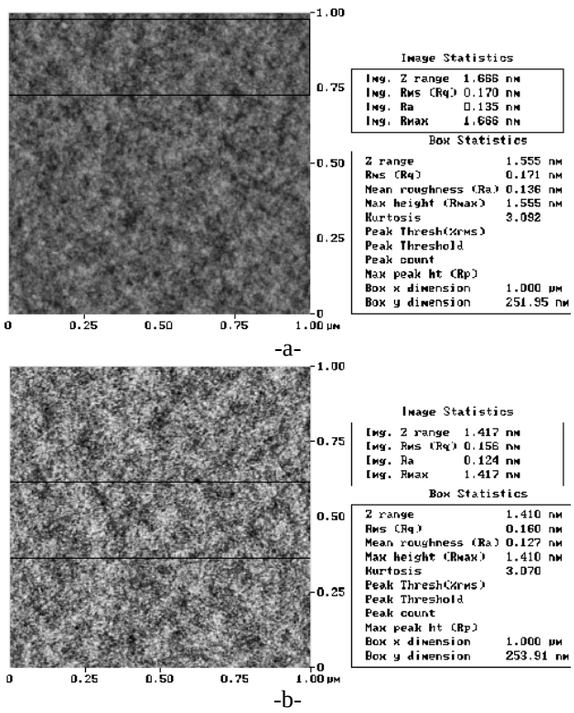

Figure 2: AFM investigations of SiO_2 surface microroughness (a) without plasma, and (b) after 25s treatment.