Change of tensile strength of sintered soda-lime glass beads: Consideration from sintering mechanism

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It is considered that planetesimals are formed by dust aggregates by mutual collision and coalescence. However a couple of outstanding problems remain in their formation process. We performed laboratory experiments in order to study the change of the strength of the sintered material because it is an important parameter that controls impact phenomenon. The change in the strength due to sintering can be one of the important changes of physical properties of dust aggregates, which may occur in the protoplanetary disks.

The samples used in our experiments were soda-lime glass bead of 5 mm in diameter. Two glass beads were put into an alumina cylinder with a weight on the top of upper particle, and sintered. The sintering temperatures were 570, 600 and 630^{o}C, and heating durations were 0.5 to 120 hours.

The relationship between neck radius and tensile strength of the array shaped sintered glass beads was investigated. The tensile strength of the samples sintered at 600^{o}C was proportional to the cross-section of the neck when they were sintered for 30 to 120 hours. On the other hand, there was large scatter in tensile strength and neck radius for the samples sintered for 4 to 30 hours. However, the 4 hour-sintered glass beads' tensile strength was proportional to the neck radius. The morphology change of the cross-section was observed using polarization microscope. It is changed from heterogeneous to homogeneous with heating duration.

Sintering mechanisms are diffusion, viscous flow and evaporation-condensation, and mass transfer rate for each mechanism is different, i.e., each mechanism has different power-law relationship between neck radius and heating duration. Therefore, it is able to distinguish which mechanism is mainly driving at each temperature and duration, if the characteristics of the morphology alternation are identified that which mechanisms drive sintering at any temperature and duration. We will present the results of our identification of sintering mechanisms due to the morphology of the neck cross-section as well as the relationship between neck radius and heating duration. We will also discuss about the results of the samples manufactured at 570 and 630^{o}C.