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The Elastic Constants of the Constituent Phases of Dental Amalgam*

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Summary

The pressure variations of the elastic constants of the constituent phases of dental amalgam (γ–Ag_3Sn, γ_1–Ag_2Hg_3, and γ_2–$HgSn_{7-8}$) were investigated in the 0–50 kilobar range. The velocities of propagation of longitudinal and transverse ultrasonic waves were measured using an ultrasonic interferometer and a solid media pressure apparatus. Computer analysis yields the pressure dependence of the bulk modulus, shear modulus, Young's modulus, and Poisson's ratio; atmospheric pressure values are obtained by back extrapolation from the high pressure measurements. The values of these elastic constants are related to the crystallographic structures of the individual alloys. The possibility of high pressure first order polymorphic transitions in γ and γ_2 is also discussed.

INTRODUCTION

There have been numerous studies completed on the physical properties of dental amalgam. However, most of these investigations have observed the responses of amalgam to certain physical tests; less effort has been made to explain what is responsible for the

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observed behavior and how physical properties are related to the structure and composition of dental amalgam. In a previous paper,[1] the authors have described the experimental techniques used and the measurements made of the elastic constants of dental amalgams as a function of pressure in the range 0–50 kilobars. In order to develop a model which explains the elastic properties observed, it was necessary to examine the elastic constants of the constituent phases of amalgam as well. This paper presents the results of that investigation of the elastic constants of γ–Ag_3Sn, γ_1–Ag_2Hg_3, and γ_2–$HgSn_{7-8}$. In the final paper of this series,[2] the authors develop a model of the elastic constants of amalgam based on its composition and structure and on the elastic constants of the constituent alloys.

Materials

Fifty-gram Ag_3Sn samples (74.5 atomic % Ag, 25.5 atomic % Sn) were prepared by melting silver and tin shot under vacuum in vycore tubes; 99.999% pure elements were used. The molten alloys were shaken and slowly cooled to homogenize the samples. The specimens, cut in the form of 1-cm diameter, 2-mm 1 long cylinders, were cold worked and annealed at 450°C for 24 hr. X-ray diffraction patterns verified that the specimens were single phase γ–Ag_3Sn; metallographic examination after polishing and etching showed that the crystallite size was small.

Since the γ_2 phase region of the mercury-tin equilibrium phase diagram is quite broad, $HgSn_{7-8}$ samples were prepared in the middle of the range—13.4 weight % Hg and 86.6 weight % Sn. The samples were melted in evacuated, sealed vycore tubes and were cooled slowly. Specimens were cut, cold worked, and annealed for 24 hr. X-ray diffraction studies and metallographic examination showed that the specimens were single phase γ_2.

γ_1–Ag_2Hg_3 samples were prepared by triturating 200-mesh silver powder with 71 weight % mercury in a Wig-L-Bug for 1 min. The specimens were condensed in a 1-cm cylindrical die and were allowed to set for 10 days. The specimens were shown to be single phase γ_1 by x-ray diffraction.

The velocities of longitudinal and shear ultrasonic waves were measured in each alloy at pressures up to 50 kb. using the technique discussed in the previous paper.[1]