Heat Treatment Strengthens Human Dentin

HAYASHI Mikako and EBISU Shigeyuki
(Graduate School of Dentistry)

Journal of Dental Research, **87**, 762-766 (2008)

Preventing tooth fracture is an urgent issue for clinical dentistry, since tooth fracture has become one of major courses for tooth loss. We found that human dentin can be strengthened by heating. Beam-shaped dentin specimens were obtained from the crowns of human third molars, and arranged so that the dentinal tubular orientations run parallel or perpendicular to loading surfaces. The flexural strength of dentin in the parallel specimens was 2.4 times greater after heating between 110 ˚C to 140 ˚C for 1 hour (Fig 1). The X-ray diffraction analyses suggested that shrinking of the lateral packing of the Type I collagen triple-helices from 14 Å to 11 Å is the probable cause of strengthening heated dentin (Fig 2). This finding may help with developing a new treatment to prevent fracture of non-vital teeth after restoration.

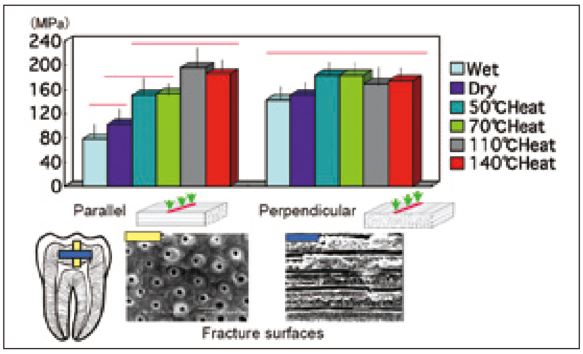

Fig. 1 Flexural strength of human dentin after heating. Dentinal tubule orientations of beam-shaped specimens obtained from coronal central portions of human third molars were organized to run parallel or perpendicular to loading surfaces. Flexural strength in the parallel specimens was 2.4 times greater after being heated between 110 to 140˚C for one hour.

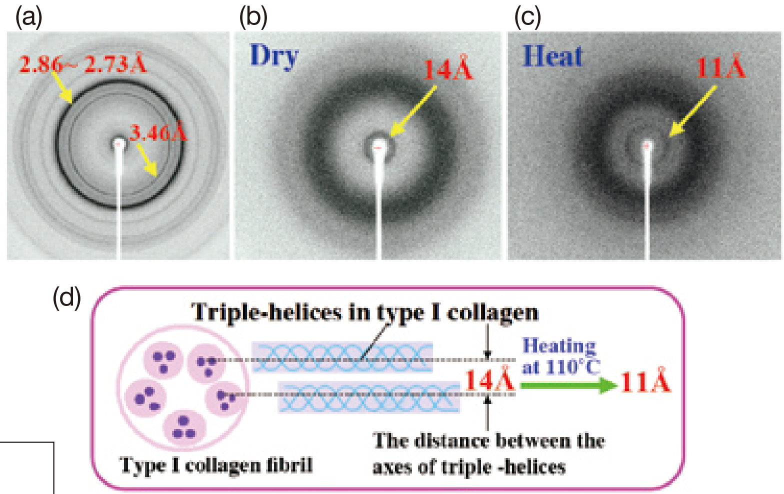

Fig. 2 Lateral packing of dentin collagen before and after heating the specimen was examined by X-ray diffraction patterns. A specimen without demineralization showed the Bragg diffraction rings originated from hydroxyapatite crystals and collagen (a). The distance between the axes of the collagen triple-helices, which is acknowledged to be 14 Å under the wet condition (b, d), shrunk to be 11 Å after heating at 110˚C for one hour (c, d).

Enhancement of Thermoelectric Efficiency in PbTe by Distortion of the Electronic Density of States

KUROSAKI Ken and YAMANAKA Shinsuke
(Graduate School of Engineering)

Science, **321**, 554-557 (2008)

Thermoelectric energy is realized by a power-generation device that is designed to convert waste heat into electrical energy. The efficiency of the device is linked to the thermoelectric properties of the generator materials and the temperature gradient across the device. The effectiveness of the thermoelectric materials is determined by the dimensionless thermoelectric figure of merit, $ZT = S^2\sigma T/\kappa$, where S, σ, T, κ are, respectively, the Seebeck coefficient, electrical conductivity, absolute temperature, and thermal conductivity. The most important issue in thermoelectric research is identifying materials with high ZT, namely with large S as well as low κ with moderate σ. The best thermoelectric materials currently used in devices are Bi_2Te_3-based alloys with a maximum ZT of around 0.8. $ZT \approx 0.8$, which translates to a device efficiency of several %, was a practical upper limit. In developing a thermoelectric power generator for the consumer market, a key factor is the achievement of a device efficiency of at least 15 %, corresponding to $ZT \approx 1.5$ or more.

The outstanding challenge in thermoelectric materials has been the enhancement of the Seebeck coefficient through distortion of the electronic density of states. Here we show a successful implementation of this approach through the use of resonant impurity levels in thallium doped lead telluride. Such band structure engineering results in a doubling of ZT to above 1.5. Use of this new physical principle in conjunction with nanostructuring to lower the thermal conductivity will further enhance the ZT and enable widespread use of thermoelectric systems for sustainable energy.

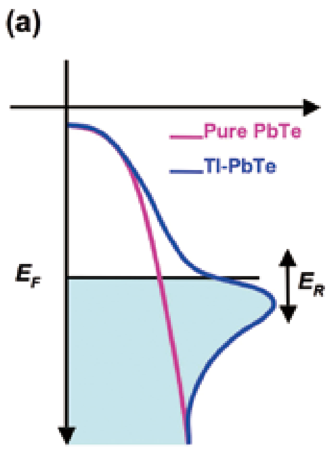

Fig. (a) Schematic representation of the density of electron states of the valence band of pure lead telluride contrasted to that of thallium doped lead telluride in which a resonant level increases the density of states near a specific energy level E_R. The figure of merit is optimized when the Fermi energy of the holes in the band is slightly above E_R.

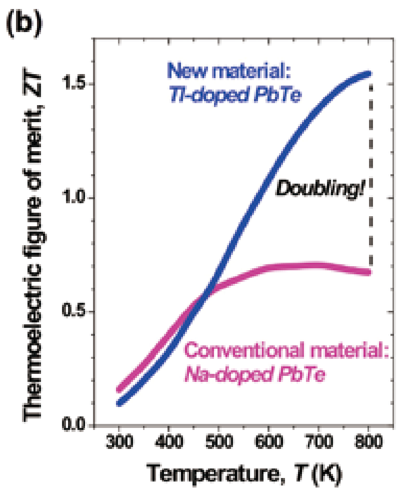

Fig. (b) The figure of merit (ZT) of the thallium doped lead telluride, compared to that of a reference sample of sodium doped lead telluride.