MEB-2005-027

TO : 541/Materials Engineering Branch/Michael Viens

FROM : 541/Materials Engineering Branch/Len Wang/Swales

SUBJECT : Elastic Properties Measurements for Beryllium Alloys

ATTCH : Brush Wellman Material Certificates 10858

REFs : 1. Vibrating Plate Test for Elastic Properties Measurements, GSFC-MEB memo MEB-2005-026, 8/31/05
2. Metals Handbook, ASM international, 10th ed., Vol. 2, p. 683.
3. Smithells Metals Reference Book, Brandes, 6th ed., p.15-2.

Introduction

In supporting the JWST project, elastic properties of three beryllium alloys of square plate samples were measured from room temperature to cryogenic temperatures (~10 K) using the vibrating plate method. This memo is to document the results.

Conclusions

All three alloys exhibit nearly identical elastic properties and temperature dependence. Slight differences in Poisson's ratio among the alloys were observed. The difference seems to be related to the purity of the alloys.

Materials and Experiment

One square plate sample (100x100x1 mm) for each of the three beryllium alloys was obtained from Brush Wellman. The alloys' specification, average grain size, purity, and density are listed in Table 1. Mechanical properties and composition analysis can be found in the attached material certificates from Brush Wellman. The main impurity in the alloys is beryllium oxide.

Table 1. Samples information

Alloy spec	Lot Number	Revision/Type	Grain size, μm	Purity, %	Density, %
O-30-H	H1104		7.7	99.7	100.10
I-220-H	H1041A	A/I	7.2	98.7	99.95
S-200-F H	H1261	B/I	6.9	99.1	99.85

Elastic properties, the Poisson's ratio (ν), and Young's modulus (E), were directly measured using the vibrating square plate method developed in Materials Engineering Branch, GSFC, NASA. The test is based on the measurements of two resonant frequencies of the plate vibration mode, designated as "X" and "O". Detailed test principles, setups, test procedures and data analysis can be found in Ref.1. Shear

modulus (G) is calculated using $G = E/2(1+\nu)$. The resonant frequencies of the test samples at which the tests were conducted are in the range of 1200 to 1400 Hz.

Results and Discussions

Figures 1 to 3 are test results of the three alloys. The room temperature values obtained from this test are very much in line with the literature/handbook data. For instance, Ref. 2 quoted $E = 304$ *GPa* and Ref. 3 quoted $E = 318$ *GPa* and $\nu = 0.02$. The author failed to find any cryogenic data for beryllium in the literature.

All three alloys exhibit nearly identical elastic properties and very steady temperature dependence, i.e. the modulus is nearly a constant in the test temperature range (10 to 295K). It is well known that the Poisson's ratio of beryllium alloys is extremely low. Our test data still showed slight differences in Poisson's ratio among the alloys. The difference seems to be related to the purity level of the alloys.

It was noticed that the air damping could lower the resonant frequency considerably and unevenly for the two vibration modes. It is desirable that the test is always conducted in vacuum (1 torr or better). Our test on the beryllium samples showed that air damping at one atmosphere can suppress the resonant frequencies of mode X and mode O of the samples by ~20 and 35 Hz, respectively. This will result in a substantial underestimate of the Poisson's ratio since the resonant frequencies of the two modes for beryllium is already very close. Air damping does not cause appreciable error in the modulus measurements of the beryllium.

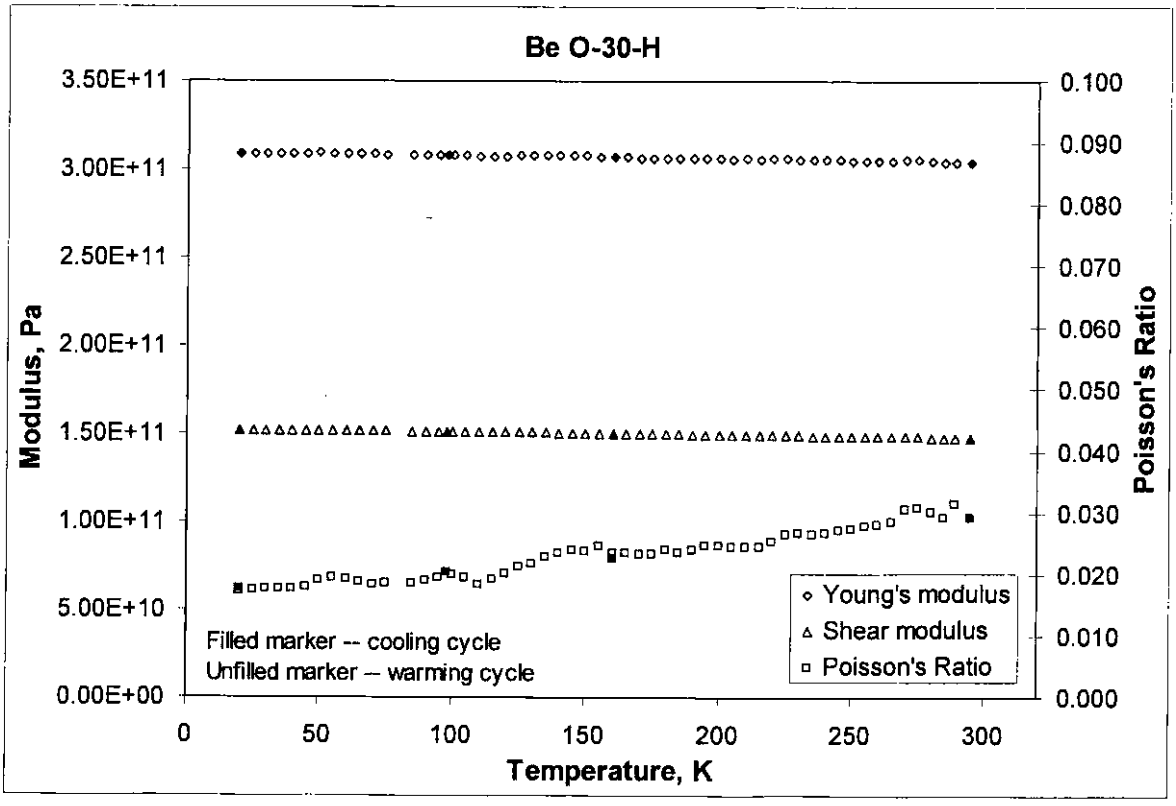

Figure 1. Results of O-30-H.

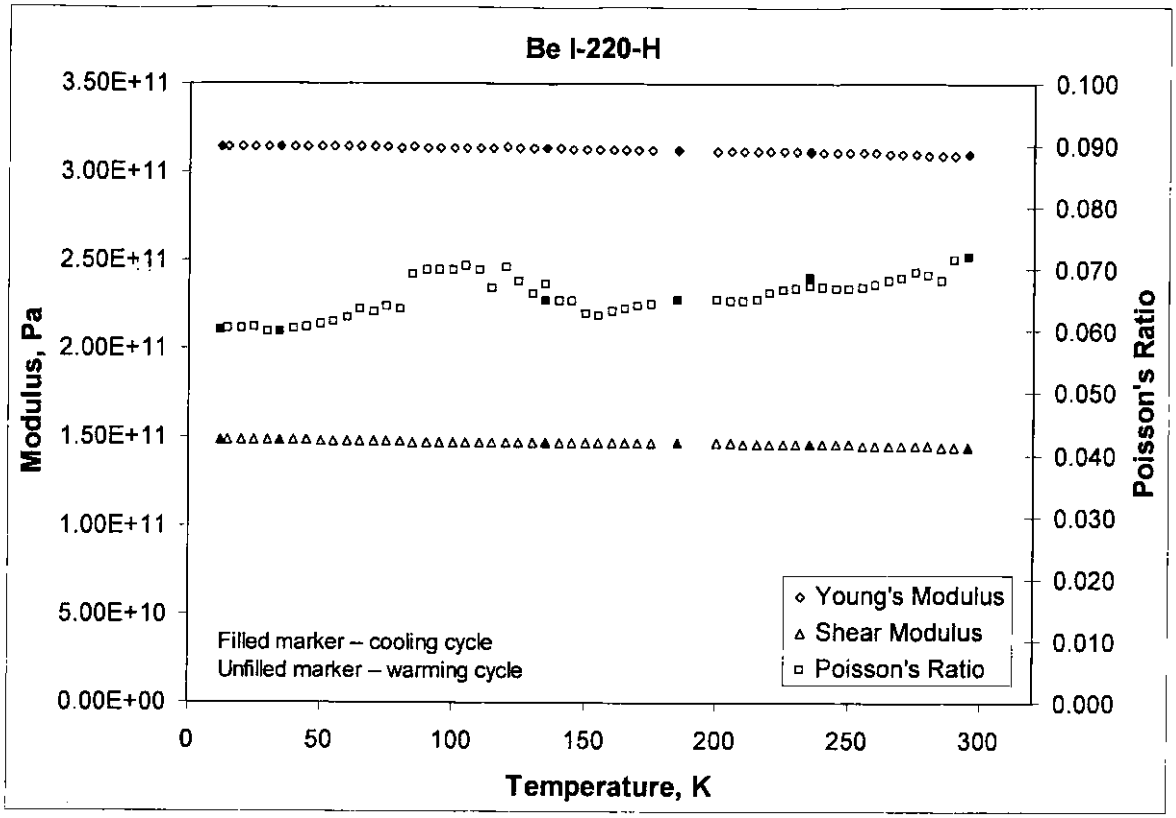

Figure 2. Results of I-220-H.

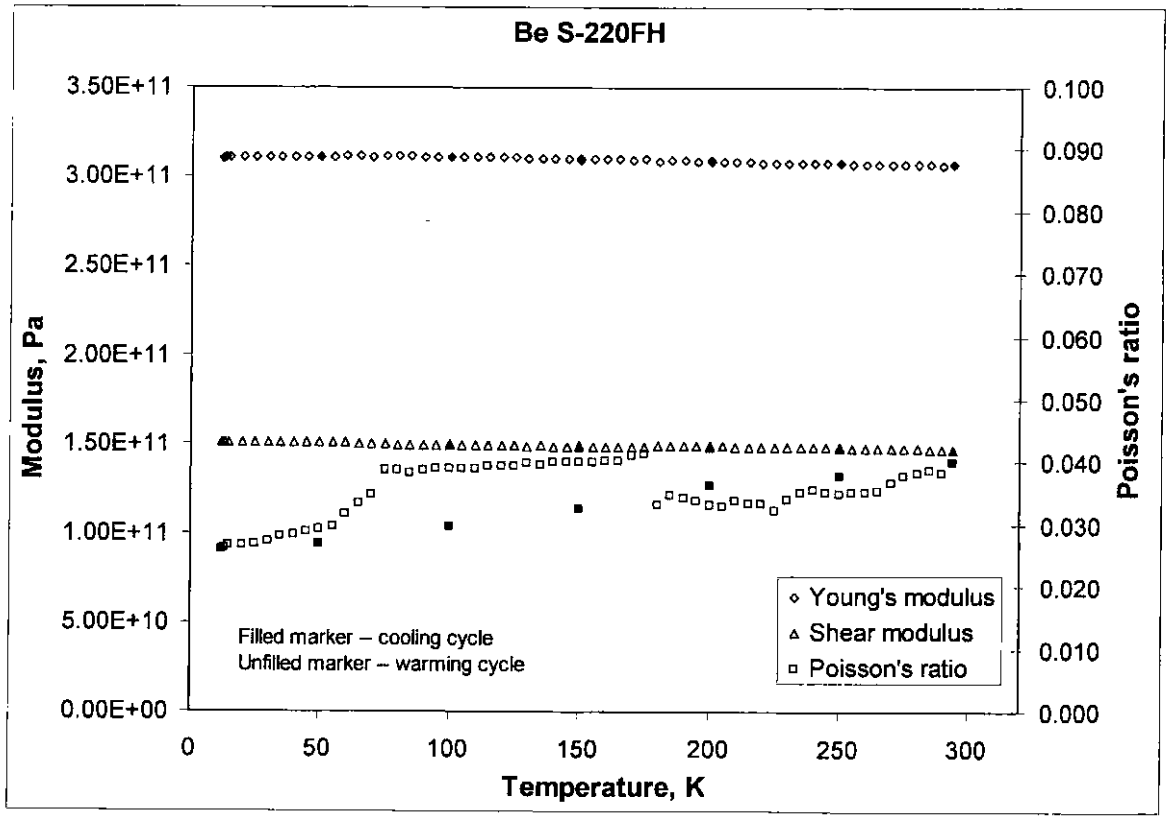

Figure 3. Results of S-220-F H

Acknowledgement

This work was a group effort. Brain Harris/541 and Carl Taylor/541 helped to set up the tests and conduct the experiments. Chris Hoffman/541/Swales created the Labview auto acquisition program.

Please contact the author for tabular data of the test results.

Len Wang, Ph.D.

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