

## **Creep of beryllium pebbles after neutron irradiation to 6000 appm helium production**

Vladimir Chakin<sup>1</sup>, Rolf Roll<sup>1</sup>, Milan Zmitko<sup>2</sup>

<sup>1</sup>*Institute for Applied Materials - Applied Materials Physics, Karlsruhe Institute of Technology, Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen, Germany*

<sup>2</sup>*Fusion for Energy, c/ Josep Pla, nº 2, Torres Diagonal Litoral Edificio B3, 08019 Barcelona, Spain*

Beryllium pebbles with 1 mm diameter are the reference neutron multiplier material in the Helium Cooled Pebble Bed (HCPB) blanket of ITER. High energy fusion neutrons cause swelling of the beryllium pebbles at the HCPB operation temperatures to 923 K. The radiation-induced swelling of beryllium as well as different thermal expansions of the beryllium pebbles and the structural material can cause the high thermal stresses in the pebble bed. Thermal creep of the pebbles should reduce the stresses because the relaxation. Neutron irradiation leads to degradation of mechanical properties, what expresses in the hardening and the embrittlement. This radiation effect hinders the effect of the relaxation.

In this study, creep properties of beryllium pebbles with 1 mm diameter produced by Rotating Electrode Method (REM) at NGK, Japan were studied. These beryllium pebbles were irradiated in the HFR, Petten, the Netherlands, at temperatures of 643, 723, 833, 923 K to 6000 appm helium production. The creep tests of individual pebbles were performed at temperatures which were equal to the irradiation temperatures by using of three different loadings per each temperature. For two lowest irradiation temperatures of 643 and 723 K, no creep effect was observed. The radiation hardening only occurs that manifests itself in significant reduction of the pebble deformation under loading. At higher irradiation temperatures of 833 and 923 K, the creep rates have significant values. The creep rates strongly depend on the testing temperatures and the loadings. At high irradiation temperatures the ability of beryllium pebbles to the significant deformation under applied loadings should provide the complete relaxation of the internal stresses in the beryllium pebbles.

### **Corresponding Author:**

Dr. Vladimir Chakin

[vladimir.chakin@kit.edu](mailto:vladimir.chakin@kit.edu)

Institute for Applied Materials - Applied Materials Physics,  
Karlsruhe Institute of Technology, Hermann-von-Helmholtz-Platz  
1, 76344 Eggenstein-Leopoldshafen, Germany

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**Springer Handbook of Experimental Fluid Mechanics** Cameron Tropea, Alexander L. Yarin, John F. Foss, 2007-10-09  
Accompanying DVD ROM contains all chapters of the Springer Handbook Page 3 of cover **Packaging of High Power Semiconductor Lasers** Xingsheng Liu, Wei Zhao, Lingling Xiong, Hui Liu, 2014-07-14 This book introduces high power semiconductor laser packaging design The challenges of the design and various packaging and testing techniques are detailed by the authors New technologies and current applications are described in detail *Metal Treatment and Drop Forging*, 1964 **Alloys Index**, 1985 **Engineering Properties of Ceramics** James F. Lynch, C. G. Ruderer, Battelle Memorial Institute, W. H. Duckworth, 1966 This Databook of engineering properties of ceramics supersedes the Materials Selection Handbook issued in October 1963 as RTD TDR 63 4102 and its two supplements dated May 1964 and April 1965 The materials covered are principally refractory inorganic compounds in the form of monophase crystalline ceramics Exceptions are the coverage of selected refractory composite materials and intermetallic compounds as well as metalloid elements of boron silicon and germanium Excluded are glasses carbons graphites and compounds melting below about 2000 F 1200 C Properties given are those pertinent to structural engineering The data are in a format designed to permit comparison and selection of materials as well as to provide details on each specific material Discussions of factors affecting property values and structural application of brittle materials also are included Metals Abstracts, 1984 Industrial Diamond Abstracts, 1959 *Industrial Diamond Review*, 1959 **Classed Subject Catalog** Engineering Societies Library, 1965 **Mechanical Engineering**, 1960 **The Engineer**, 1956 *A Summary of the Available Data on the Creep Properties of Beryllium : Technical Notes* G.A. Pickup J. Winston, 1958 *Beryllium Science and Technology* D. Webster, 1979 This beryllium treatise was made possible by the expertise and hard work of members of the Joint US UK Working Group on Beryllium JOWOG 22 which was set up in the 1960s to allow a controlled exchange of technical information on the science and application of beryllium between the two countries The leading roles in JOWOG 22 of Dr Lee Roberts of the Lawrence Livermore Laboratory and Dr Geoffrey Ellis of the Atomic Weapons Research Establishment A WRE at Aldermaston are particularly noteworthy Excerpts from some of the material in this book were presented at an international conference Beryllium 77 in London in October 1977 The conference which was superbly organized by Dr John Martin and his co workers at A WRE was sponsored by the Metals Society and the Institution of Metallurgists and was particularly instructive in revealing the unexpectedly strong position of the USSR in some aspects of beryllium physical metallurgy and ductility improvement Advance publicity for this book was also provided by presentations at the AlME 1977 annual meeting in Atlanta Georgia The presentations were co sponsored by the Metallurgy and Non Ferrous Metals Committees at the request of committee members John E Smugeresky and Gilbert J London D Webster G J London vii Contents 1 Introduction 1 **The Creep of Beryllium Oxide - a Literature Survey** J. W. Kelly, 1964 Tensile and Creep

Properties of Beryllium Sheet and Block from Room Temperature to 1500 F A. S. RABENSTEINE, MARQUARDT CORP VAN NUYS CALIF., 1963      Some Creep Characteristics of Beryllium-copper at 300degrees Celsius. James G Curry, 2021-09-09

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**Enhancement of Beryllium Creep Resistance by Control of Composition and Structure** Ronald L. Greene, 1973

**Methods of Production and Some Mechanical, Including Creep, Properties of Beryllium Sheet** L. Groucott D.A. Longstaff (G.C.E. Olds, J. Harvey), 1959      **Stress-Rupture and Creep Properties of QMV Beryllium Metal** J. N. Hurd, R. G. O'Rourke, W. W. Beaver, 1960 Data for the stress rupture and creep properties of QMV beryllium and associated materials including those of a higher oxide content are presented The temperature range covered was from room temperature to 1500 F The data showed that the addition of the oxide improved the creep strength of the beryllium The data are discussed from the viewpoint of describing some of the phenomenological aspects of the creep behavior of beryllium In particular a creep equation for elevated temperature description is presented and the variations of the parameters therein appearing are described Attention is drawn to the effect of using creep stresses which exceed tensile elastic limits Data correlations based on the creep equation and methods for calculating the activation energy for the creep of beryllium at elevated temperatures are given The product of the minimum creep rates by the corresponding rupture times is discussed and the conclusion is drawn that the activation energy for creep equals that for rupture      **Development of Pressurized Tube Specimen for Creep Testing of Beryllium** , 1990 The purpose of this work was to demonstrate that creep tests could be performed on beryllium in the same pressurized tube geometry as is commonly used in the FFTF MOTA

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