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Zoz launching PM2000

revitalization of Plansee's ODS-19YAT

ODS-20YAI (PM2017-AM) and NFA-14YWT (PM2018)

high-temp. & corrosion-resistant/irradiation-tolerant ODS/NFA-steels/powder from the shelf

Wenden/Germany

Any modern society considers sustainability, saving resources and increasing performance every day and our all future will be ruled by materials as never before. Based on general materials limitation, goal (a) is "making more with less" and since materials consumption contradicts with such limited resources, goal (b) is recycling. Both are leading to advanced materials processing with the utilization of larger surface and finer structures leading to nanostructures.

High Kinetic Processing (HKP) has been proven as a major route for reducing materials grainsize in large volume at economic manufacturing and cost capability where the "nanostructure-making-equipment", the Zoz-Simoloyer® is well-known including technology and key advantages.

Nanostructure and innovative solutions in green-/cleantech manufactured with Zoz Technology

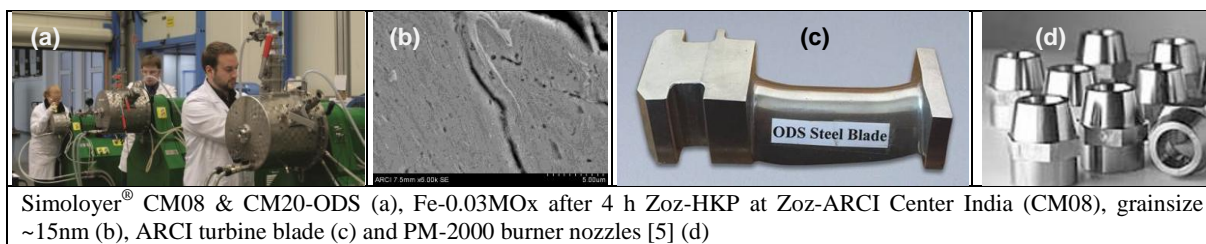


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oxide dispersion strengthening | ODS & Nanostructured Ferritic Alloys

One major focus at Zoz-customers is concentrated on the development and processing of Oxide Dispersion Strengthened Ferritic Steels (ODS). Due to their high temperature stability and strength along with a high irradiation tolerance, ODS-steels represent promising candidates for nuclear fusion and 4th gen. fission reactors likewise for components in gasturbines/aero- and combustion engines exposed to high temperature and high corroding environment [1-4].

This target does not at all contradict with the "green/cleantech-company" understanding of Zoz since the pure political German "no" to nuclear energy does not efficiently reflect global environmental responsibility.



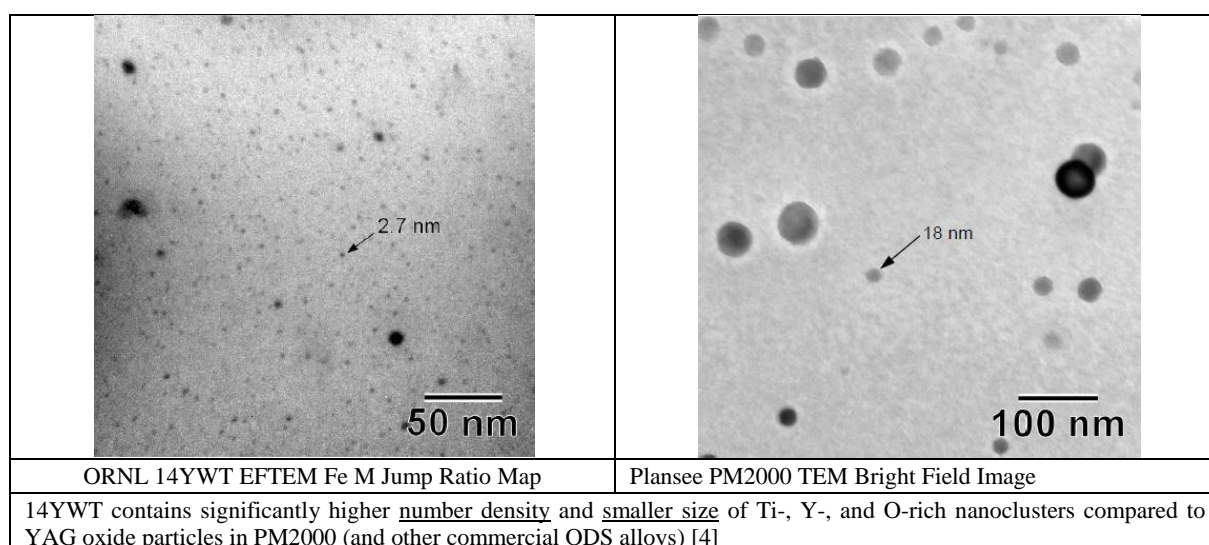
Particularly with the goal of achieving better resistance to radiation damage, Nanostructured Ferritic Alloys (NFA) with a dense dispersion of <10nm oxides occurring intra- and intergranularly as precipitates of complex oxides e. g. Y₂Ti₂O₇ formed after a dissolution of starting Y₂O₃ under the presence of Ti during intense/extended HKP (>20h, >8m/s MRV) and subsequent heat treatment (>1.000°C), were developed [6, 7].

Due to a general renaissance of powder metallurgy (PM) by additive manufacturing processes (AM, ALM...), also conventional ODS-materials, where coarser "original" oxides >10nm located predominantly on grain boundaries or former particle boundaries [6] homogeneously dispersed by HKP (<4h, >8m/s MRV) opened another focus. The naturally irregular/equiaxial particles after HKP can be modified in morphology by so called spheroidization (SPH) to better meet flowability requirements for AM or MIM [8].

The difference in oxide character and location results in lower mechanical properties of the common ODS-material [6] where economics in processing cost do determine the proper material for the particular application.

Since Zoz has been providing not only the processing equipment but also most of the larger numbers of ODS/NFA-materials (powder, 2 t approx.) in recent years, in late 2016 it has been decided to invest into the semi-commercialization of 3 dispersion strengthened materials to on-shelf availability of powder and bulk (semi-finished). Under strict information and joint understanding/agreement policy towards all customers, partners, former manufacturer and future applying industry, from whom Zoz has been and is learning a lot, a bilateral group USA/Germany has been formed [9]. A "geo-political" restriction appeared ultimate, since the Simoloyer[®] and its products as of 2016 are under full observation of BaFa (German Export Control) where e. g. military relevance of ODS and nuclear application of NFA are determining.

The goal of this joint undertaking between Zoz and core partners KIT in Germany and UCSB, ORNL as well as LANL in the USA is a commercial NFA from the shelf. Since this has never been done before, support from the US-DOE is on board and a joint submission within Euratom/INERI (International Nuclear Energy Research Initiative) based on DOE-NE's Advanced Fuels Program is planned as of August 2017.



additive manufacturing ODS | nuclear fusion / 4th gen. fission NFA

For at most economic "fast/safe resulting", two milestones have been fixed. In 2017, the former Plansee PM2000 alloy (ODS-19YAT, manufacturing by Plansee until 2006 [10]) is going to be relaunched in powder and bulk (D40xL250mm) based on the simpler fine-grain/HIP-consolidated type that e. g. the German car-manufacturer Porsche was utilizing for the injection nozzle of its GT4-engine [8] to serve under extremely high corrosive environment at high temperature. Under mutual understanding with Plansee [11], the name of PM2000 will survive. Also an immediate goal is a new material PM2017 (20YAl) with 1% more Cr and zero Ti (compared to PM2000) with a focus on AM consolidation routes including MIM.

brand	chem. composition (starting mat.)	ID	origin	t. b. on shelf
PM2000	Fe-19Cr-5.5Al-0.5Ti-0.5Y2O3	19YAT	ODS-PM	fine-grain/HIP only, D40xL250mm
PM2017	Fe-20Cr-5.5Al-0.5Y2O3	20YAl	ODS-RR	powder only (AM, ALM, MIM)
PM2018	Fe-14Cr-3W-0.4Ti-0.25Y2O3	14YWT	NFA-GE	t. b. d.
chemical (basic) compositions for on shelf (a) powder and bulk (b) powder only (c) powder and t. b. d.				

If the ambitious schedule will be achieved, then the NFA-14YWT with the chemical starting composition Fe-14Cr-3W-0.4Ti-0.25Y2O3, demonstrated by GE with powder processing at Zoz [6] in large volume shall be available under the name PM2018 from that year in powder batches and small bulks.

ODS/NFA powder processing is done at the Zoz Technology Center (ZTC) in Germany, characterization of powder and bulk at core partners. For tolling HIP (PM2000) and starting materials supply, Zoz is searching for suppliers. For the upcoming (again after 10 years) availability of PM2000, Zoz is searching for the former and future customers and end user.

References:

- [1] Pei He, "On the structure-property correlation and the evolution of Nanofeatures in 12-13,5% Cr oxide dispersion strengthened ferritic steels", scientific publications KIT/Germany, vol. 31 [2014] ISBN 978-3-7315-0141-1
- [2] A. Kimura, Kyoto University and R. Lindau, Karlsruhe Institute of Technology - KIT: Development of nanoscaled ODS Steels at Kyoto University and KIT, OZ-16, 9th International | 9th German-Japanese Symposium on Nanostructures (2016), Wenden, Germany, proceedings vol. 9 p-no. P21
- [3] G. R. Odette, University of California Santa Barbara: On the Development and Characterization of a Larger Best Practice Heat of a 14YWT Nanostructured Ferritic Alloy FCRD NFA-1, OZ-Workshop 2015 at UCB, University of California at Berkeley, Department of Nuclear Engineering, Berkeley (2015-05-15)
- [4] D. T. Hoelzer, Oak Ridge National Laboratory: On the Development of Nanostructured Ferritic Alloys for Advanced Fuel Clad Applications in Nuclear Reactors, OZ-16, 9th International | 9th German-Japanese Symposium on Nanostructures (2016), Wenden, Germany, proceedings vol. 9 p-no. V02, S02
- [5] Plansee: Dispersionsverfestigte Hochtemperaturwerkstoffe, Datenblatt Werkstoffeigenschaften und Anwendungen (1998)
- [6] R. DiDomizio, S. Huang, L. Dial, J. Ilavsky, M. Larsen: An Assessment of Milling Time on the Structure and Properties of a Nanostructured Ferritic Alloy (NFA). Metall and Mat Trans A (2014) 45:5409-5418
- [7] R. DiDomizio, GE Global Research: The Effects of Processing on Precipitate Distribution and Tensile Properties of a Nanostructured Ferritic Alloy (NFA), OZ-Workshop 2015 at UCB, University of California at Berkeley, Department of Nuclear Engineering, Berkeley (2015-05-15)
- [8] authors discussion with Prof. Gerhard Leichtfried, Innsbruck, 2017-03-02
- [9] authors discussion with A. Moeslang (Karlsruhe Institute of Technology - KIT), G. R. Odette (University of California Santa Barbara), S. A. Maloy (Los Alamos National Laboratories), D. T. Hoelzer (Oak Ridge National Laboratory), 2016-11 through 2017-04
- [10] Communication Plansee Nederland, 2017-04-05
- [11] authors discussion and communications with Plansee Composite Materials GmbH Lechbruck am See, 2016-11 through 2017-04-11