Radiation Effects in Superconducting Magnets and Materials
Wroclaw University of Technology, Poland
12th – 14th May 2014

REPORT ON RESMM'14 WORKSHOP

Elena Quaranta

Collimation Upgrade Specification meeting
June 6th 2014

Workshop's webpage - INDICO

https://indico.fnal.gov/conferenceOtherViews.py?fr=no&showSession=all&detailLevel=all&confId=7702&view=standard&showDate=all

Workshop on Radiation Effects in Superconducting Magnets and Materials 2014 (RESMM'14)

from Monday, May 12, 2014 at **08:00** to Thursday, May 15, 2014 at **11:00** (Europe/Warsaw)
at **Wroclaw University of Technology**
Wybrzeze Wyspianskiego 27, 50-370 Wroclaw POLAND

International Organizing Committee:

Maciej Chorowski (WrUT)

Michael Eisterer (ATI)

Rene Flukiger (CERN)

Mike Lamm (FNAL)

Nikolai Mokhov (co-chair, FNAL)

Tatsushi Nakamoto (KEK)

Hiroshi Nakashima (JAEA)

Koji Niita (RIST)

Toru Ogitsu (co-chair, KEK)

Al Zeller (FRIB)

Local Organizing Committee:

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Jarosław Poliński (WrUT)

Błażej Skoczeń (CUT)

Sławomir Wronka (NCNR)

Piotr Wilk (WTP)

Agnieszka Pelc (Coordinator, WrUT)

RESMM'14: Objectives

Focus on establishing radiation damage limits and design of large superconducting systems, primarily for the Mu2e and Comet experiments, but also for ITER, LHC, FRIB and muon collider magnets.

- Design of superconducting magnets for high radiation environment
- Modeling of radiation effects in magnets and material response
- Benchmarking experiments

What I presented…

Comment by B. Skoczen: ACOUSTIC DEVICES for long-distance and on-line monitoring during destructive tests in HiRadMat facility?

What I found interesting for us...

Evolution of radiation induced micro-damage in the materials used in particle accelerators design

Błażej Skoczeń, Aneta Ustrzycka
Centre for Particle Accelerators Design, Cracow University of Technology

Collimator lifetime?!

The main task of the research

Task

We need to determine the lifetime of irradiated components, subjected to periodic thermo-mechanical loads in the course of their service

Method

Well calibrated constitutive model of micro-damage evolution in the irradiated components

State of art

State of the art in radiation induced damage

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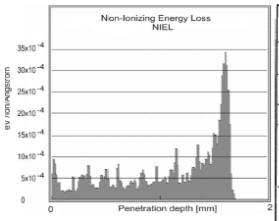
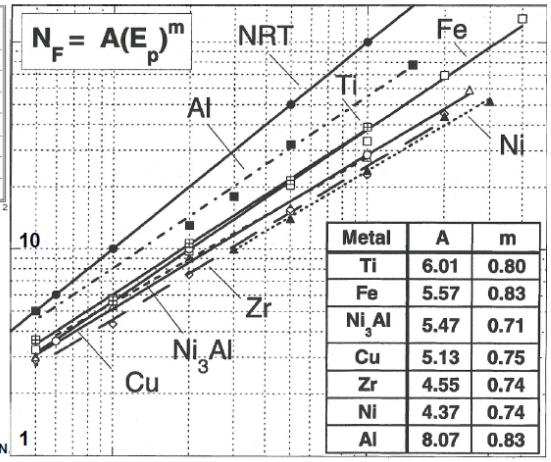
Irradiation induced defects in the lattice



NIEL profile for copper irradiated by hydrogen 30MeV ions

Number of Frenkel defects created by a cascade as a function of kinetic energy of primary knock-on atoms



Metal	A	m
Ti	6.01	0.80
Fe	5.57	0.83
Ni_3Al	5.47	0.71
Cu	5.13	0.75
Zr	4.55	0.74
Ni	4.37	0.74
Al	8.07	0.83

Source: D.J. Bacon, F. Gao, Yu.N Osetsky, JNM 276, 2000

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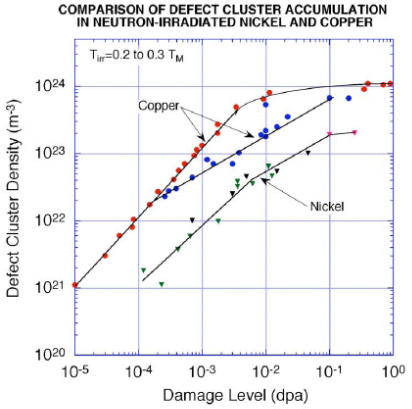
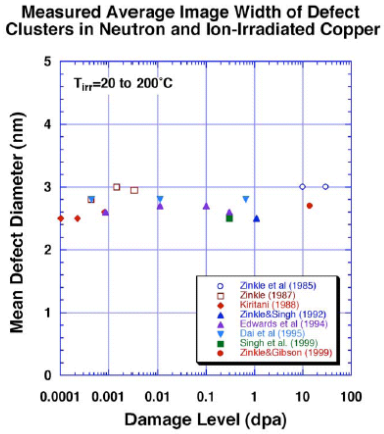
Irradiated metals and alloys: Copper





Source: S.J. Zinkle „Microstructure evolution in irradiated metals and alloys: fundamental aspects", Italy, 2004

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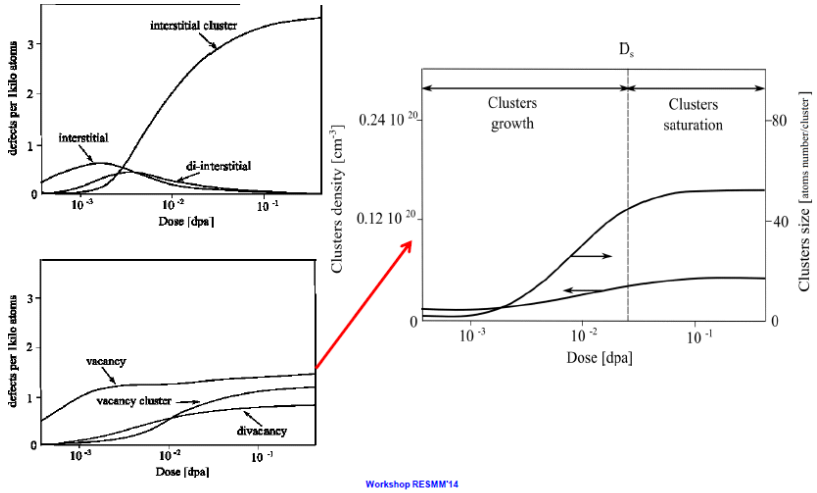
Defect concentration during irradiation - Aluminium

(for Al, after Verbiest and Pattyn, 1982)



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Research programme

Experiments including neutron irradiated samples subjected to multiple loading/unloading technique

↓

Building well calibrated multi-scale 3D constitutive models of damage evolution in the irradiated components in the framework of CDM

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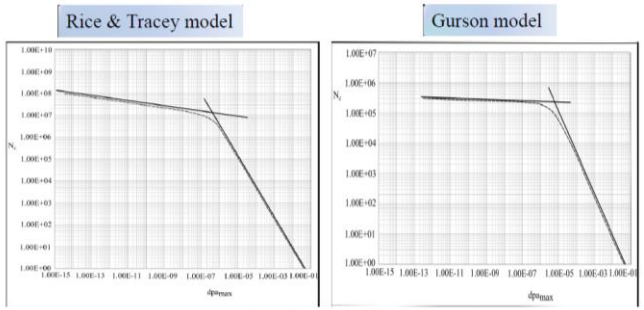
Combining CDM with fracture mechanics in order to predict transition from critical damage to fracture

↓

Computing evolution of nano/micro damage fields and macro-crack propagation in the irradiated components

Lifetime prediction



$$\log(N_c) = a + b\log(dpa_{\max})$$

Analytical formula - useful tool for estimation of number of cycles to failure

$$N_c = 10^a \, dpa_{\max}^b$$

$$N_c = \begin{cases} 10^{-1.9} dpa_{\max}^{-1.4} & for \quad dpa_{\max} \geq 10^{-6} \\ 10^{6.1} dpa_{\max}^{-0.13} & for \quad dpa_{\max} < 10^{-6} \end{cases}$$

$$N_c = \begin{cases} 10^{-1.9} dpa_{\max}^{-1.4} & for \quad dpa_{\max} \geq 10^{-5} \\ 10^{5.43} dpa_{\max}^{-0.016} & for \quad dpa_{\max} < 10^{-5} \end{cases}$$

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Conclusion

The constitutive model has to be calibrated in order to achieve correct performance and obtain reliable results in terms of number of cycles to failure as a function of dpa

What I found interesting for us...

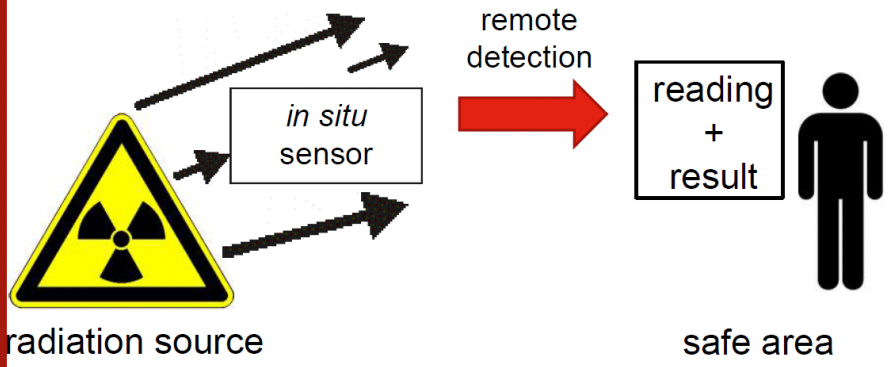
In-situ monitoring of high doses of radiation

Paweł Knapkiewicz
Faculty of Microsystem Electronics and Pho
Division of Microengineering and Photovol

RESMM 2014
Wrocław, Poland, 13 May 2014

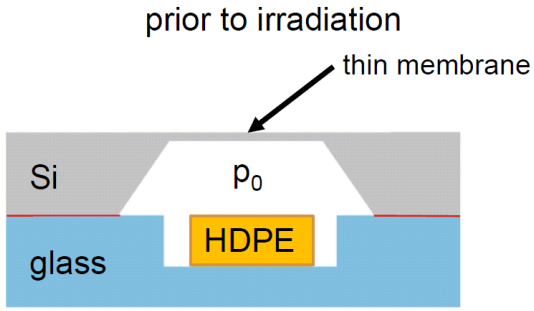
Wrocław University of Technology

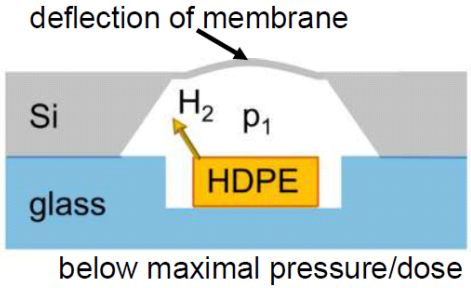
Wanted: new method of measurements of high-doses of radiation above 20 kGy



Problem: no sensors

Our new MEMS sensor - principle



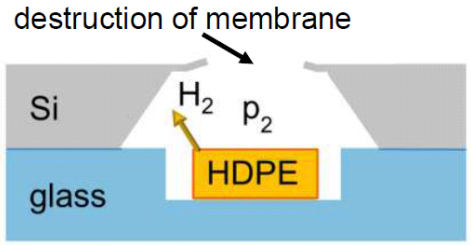


below maximal pressure/dose

Single membrane sensor

$p_1 < p_{max}$

proportional mode of detection possible



over maximal pressure/dose

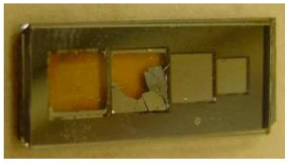
"Cascade" membranes sensor

$p_2 > p_{max}$

membrane of known mechanical properties discriminates doses

Sensors of high doses of radiation – potential application

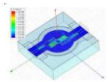
"Cascade" membranes treshold sensor



+ simple eye controll

Single membrane proportional sensor

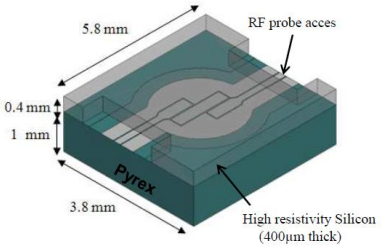
+ remote controll

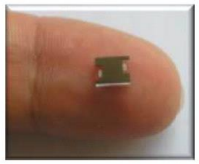


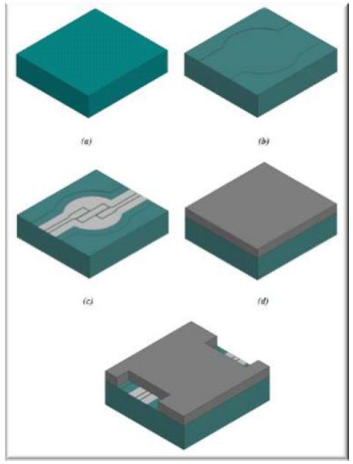
Radar

Optical

Radar remote detection based on CNRS-LAAS (Toulouse, Fance) technology







Possible applications:

- an innovative, **maintenance free surveillance system** for the new generation nuclear power plant monitoring and nuclear reactor
- **dosimeter system** in high-level-waste storage places where the high dose monitoring is needed and in all facilities where the high energy particle accelerators exist (CERN, DESY, etc.).

HRMT dose level monitoring?!

Other ideas for the future…

e^- irradiation (A. Ryazanov):

no radioactive sample after irradiation

correlation projectiles (type/energy) and damage in material needed

High doses radiation facility at NCBJ (Świerk-Poland): multipurpose LINAC up to 22MeV (6 MeV e^-, dose rate >10 kGy/min)

Summary

- Acoustic devices for long-distance and on-line monitoring in HiRadMat tests
- Combining efforts with B. Skoczen in radiation-induced damage model studies
- Passive wireless MEMS dosimeters
- e^- irradiation of collimator materials.

Wroclaw – Market Square

Thanks for your attention!