Materials Research at University of Science and Technology Beijing

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University of Science and Technology Beijing （USTB）

About

- The University of Science and Technology Beijing (USTB) which founded in 1952, is a national key university under the direct supervision of the Ministry of Education of China .

- USTB is famous for its study of metallurgy and material science, was called as Beijing Institute of Iron and Steel during 1952-1988. USTB has been supported almost all steel-making plants in China.

- While engineering is the focus, there are also programs in basic science, management, humanities, economics and law.

Schools

USTB

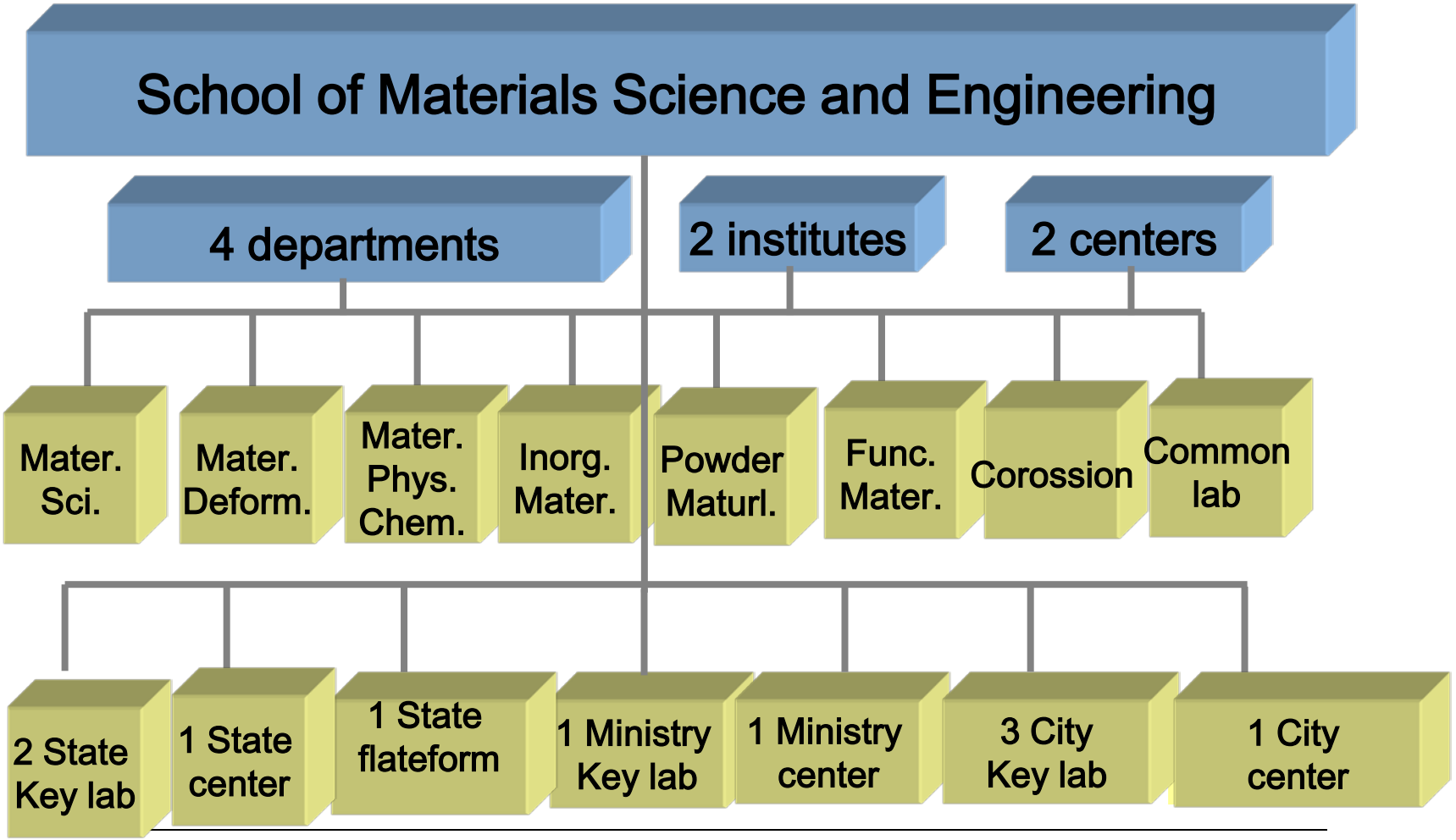
- School of Materials Science & Engineering
- School of Metallurgical & Ecological
- School of Civil & Environment Engineering
- School of Mechanical Engineering
- School of Information Engineering
- School of Economics & Management
- School of Applied Science
- School of Humanities & Social Sciences
- School of Foreign Languages
- The Graduate School
- The Continued Studying School

- Tianjin Campus
- Yanqing Campus
- Guanzhuang Campus

- **The School of Materials Science and Engineering is the largest one among 9 schools in USTB**
- **4 Departments, 2 Institutes, 2 Centers**
- **450 Ph.D students, 1000 Master students, 1500 Undergraduate students**
- **142 teachers (78 professors)**
- **51 technicians, 16 office members**

Basic Information

Structure



Department of
Materials Physics and Chemistry

- Environment Induced Cracking
- Irradiation damage in materials
- Materials Surface and Crystal Boundary
- Nano Structured Materials and Technology
- Based on Metal Physics

Department of Materials Science

- Materials Optimization and Design
- Magnetic Materials and Application
- Application Basis for Advanced Structure Materials
- Advanced Materials Basis and Materials Anisotropism
- Strong ability to prepare materials

Department of
Materials Processing and Control Engineering

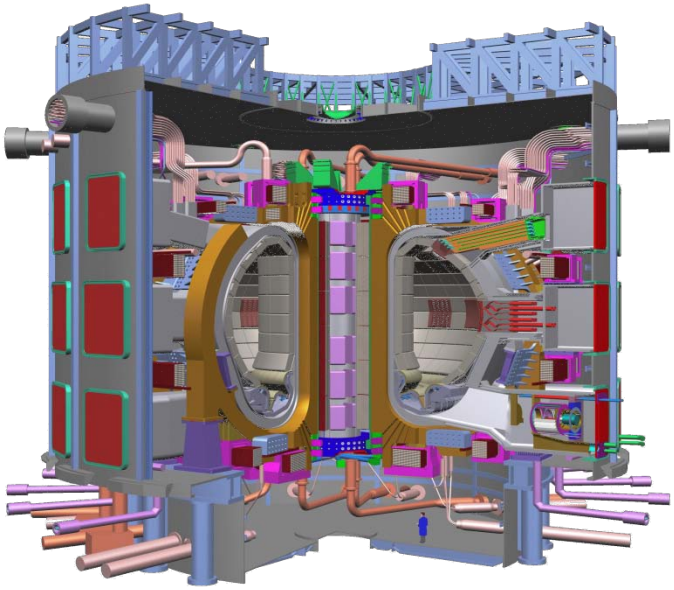
- Advanced Preparation and Processing
- Forming Processing Control and Simulation
- New Technology for Plastic Working
- Processing Theories and Structure Control
- Metal Solidification and Control
- Advanced Welding Technology

Department of
Inorganic Nonmetallic Materials

- **Advanced Ceramic Materials**
- **Inorganic Nonmetallic**
- **Researching on high energy fuel batteries, solid electrolyte sensor**

ITER

International Thermal-nuclear Experimental Reactor



EU,US,Russia,Japan,China,Korea,India

National Expert Committee on Magnetic Confinement Fusion Energy of China

13 three-year projects (13X5M$) per year (1-2 for materials)

Irradiation damage in materials, Ferritic / martensitic steel (USTB)

Low Activation Martensitic Steels

Steel	Cr	W	V	Ta	Mn	Si	C	N	B
F82H	8.0	2.0	0.20	0.04	0.50	0.2	0.10	<0.01	0.003
JLF-1	9.0	2.0	0.20	0.07	0.45	0.08	0.10	0.05	
EUROFER97	8.5	1.1	0.20	0.10	0.40	0.05	0.12	0.02	<0.001
9Cr2WVTa	9.0	2.0	0.25	0.07	0.40	0.30	0.10	0.02	

- The development of the materials with high-performance, strong resistance to irradiation swelling and low activation for the first wall and blanket structural components is the key to the fusion power system.
- The low activation martensitic steels were considered as the candidate materials in this field.

Design of CLAM steel

China Low Activation Ferritic/Martensitic (CLAM) steel

Increase W for higher strength,

More than 2wt% tungsten may lower the toughness of the steel.

2wt%W in F82H, 1 wt%W in EUROFER 97

Design composition of CLAM steel

Element	Cr	W	V	Ta	Mn	C	P	S
wt%	9.0	1.5	0.2	0.07	0.45	0.1	<0.003	0.002
Element	N	Si	Ti	Ni	Co	Cu	Nb	O
Wt%	0.02	0.01	<0.006	0.02	<0.005	<0.005	<0.001	<0.0026

Irradiation experiment

Samples

Steel	Fe	Cr	W	V	Ta	Mn	Si	C
CLAM	Bal.	8.8	1.49	0.20	0.059	0.68	--	0.13
CLAM + Si	Bal.	9.11	1.51	0.21	0.16	0.41	0.46	0.10

Electron irradiation:

Hokkaido University,Japan, JEM-ARM1300

Voltage:1250kV，Beam :1.2nA，

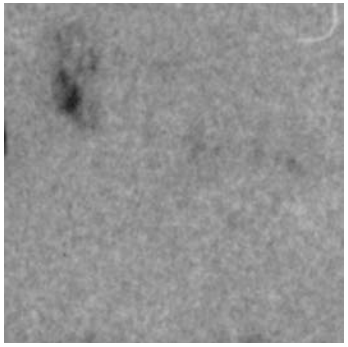
Damage rate: 2×10^{-3}dpa/s。

High voltage part

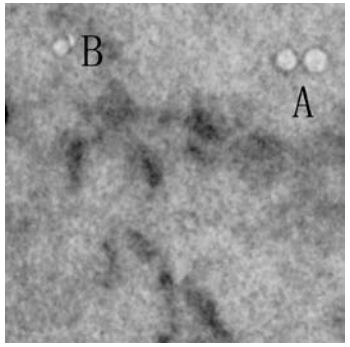
Observing table

High Voltage Electron Microscope, JEM-ARM1300
Hokkaido University, Japan

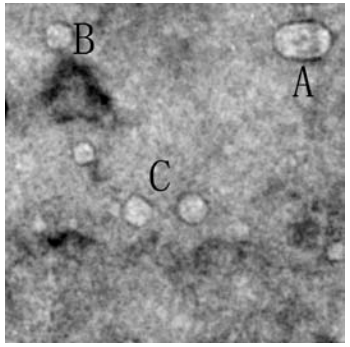
Damage change in CLAM steel without Si
Irradiation temperature: 450℃



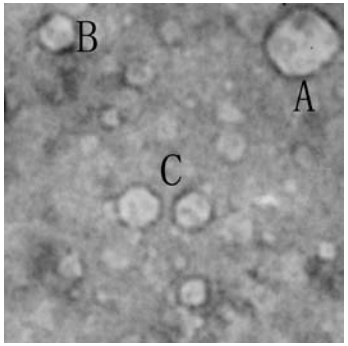
0 dpa



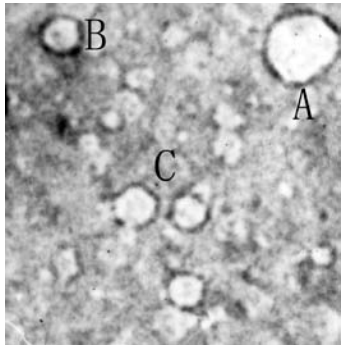
2.4 dpa



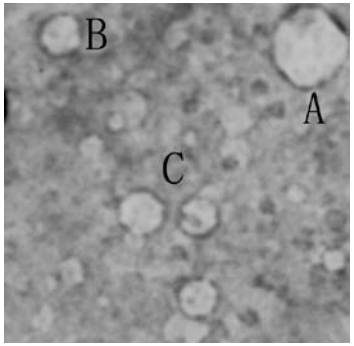
3.6 dpa



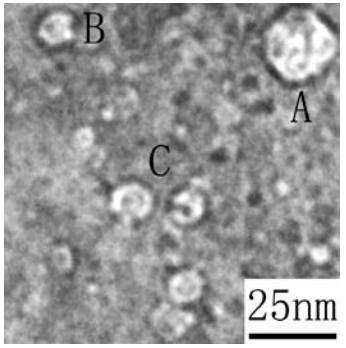
10 dpa



12 dpa

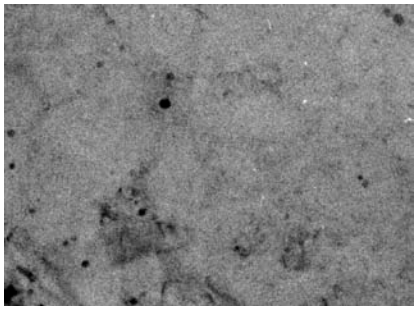


13 dpa

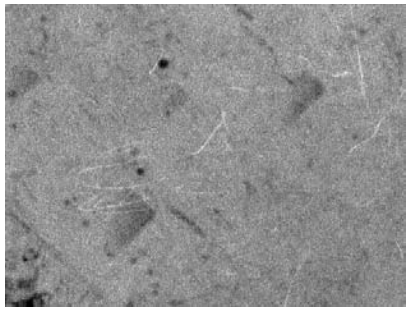


14 dpa

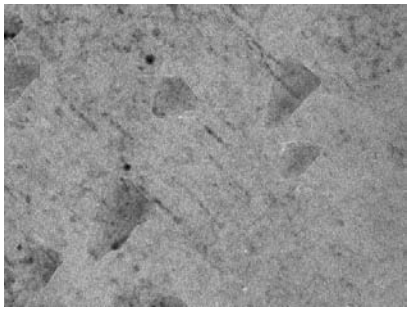
Damage change in CLAM steel with Si
Irradiation temperature: 450℃



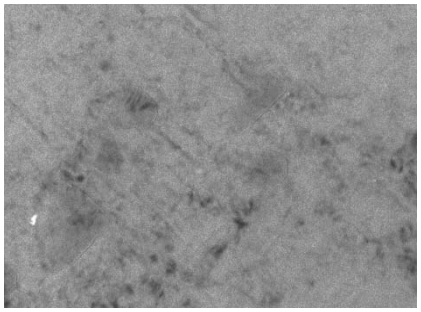
0 dpa



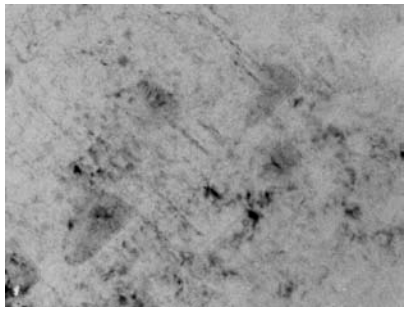
1.2 dpa



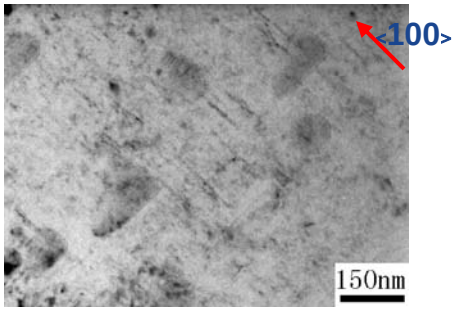
3.8 dpa



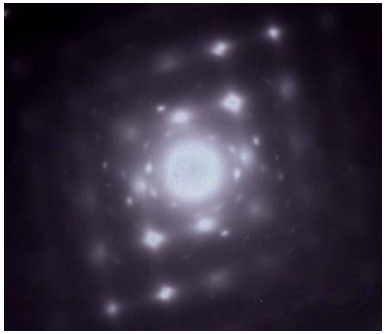
7.5 dpa



11.5 dpa



16 dpa



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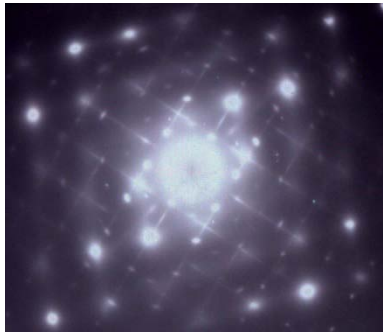
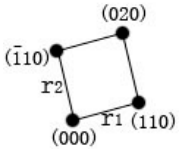
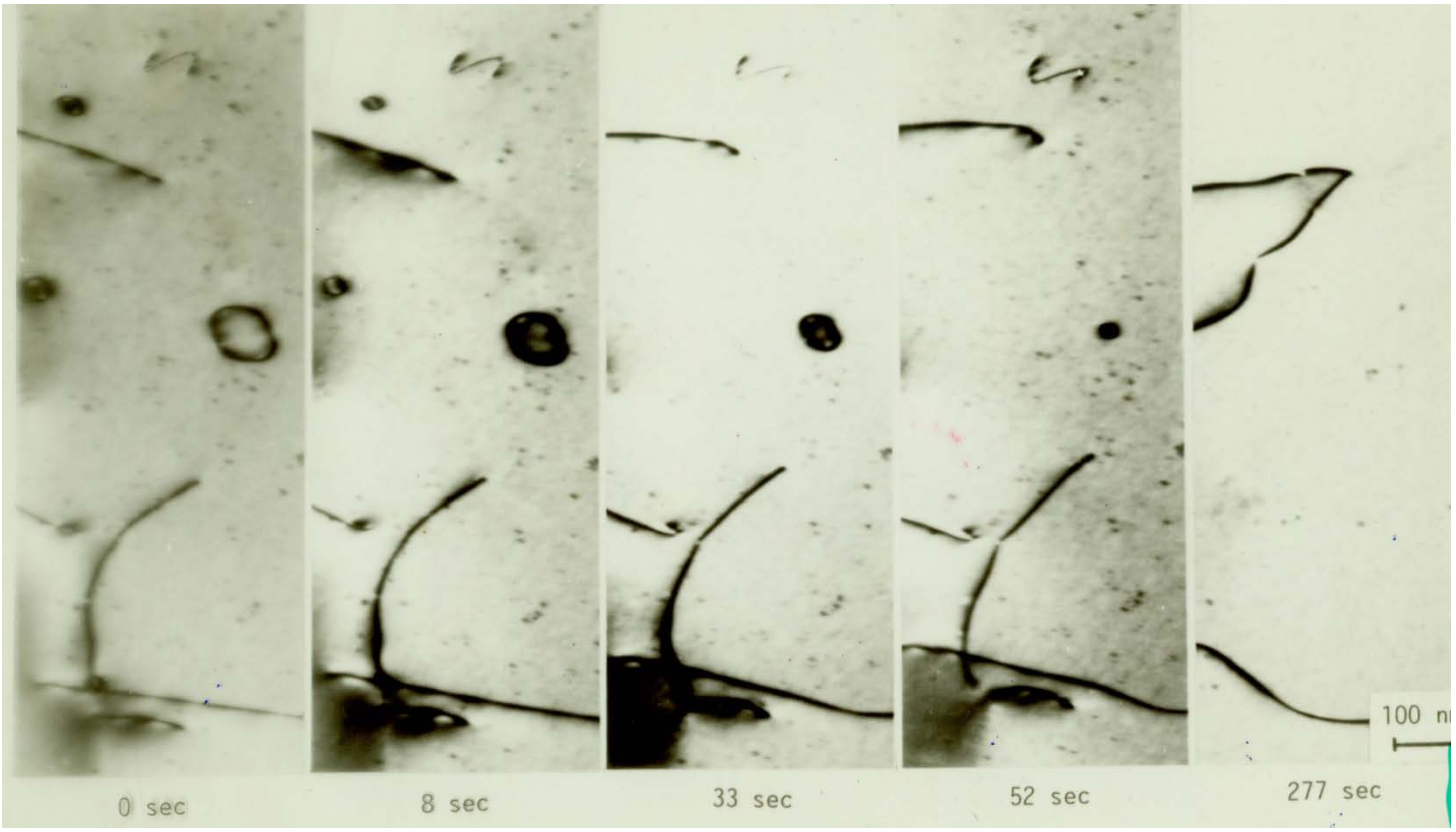


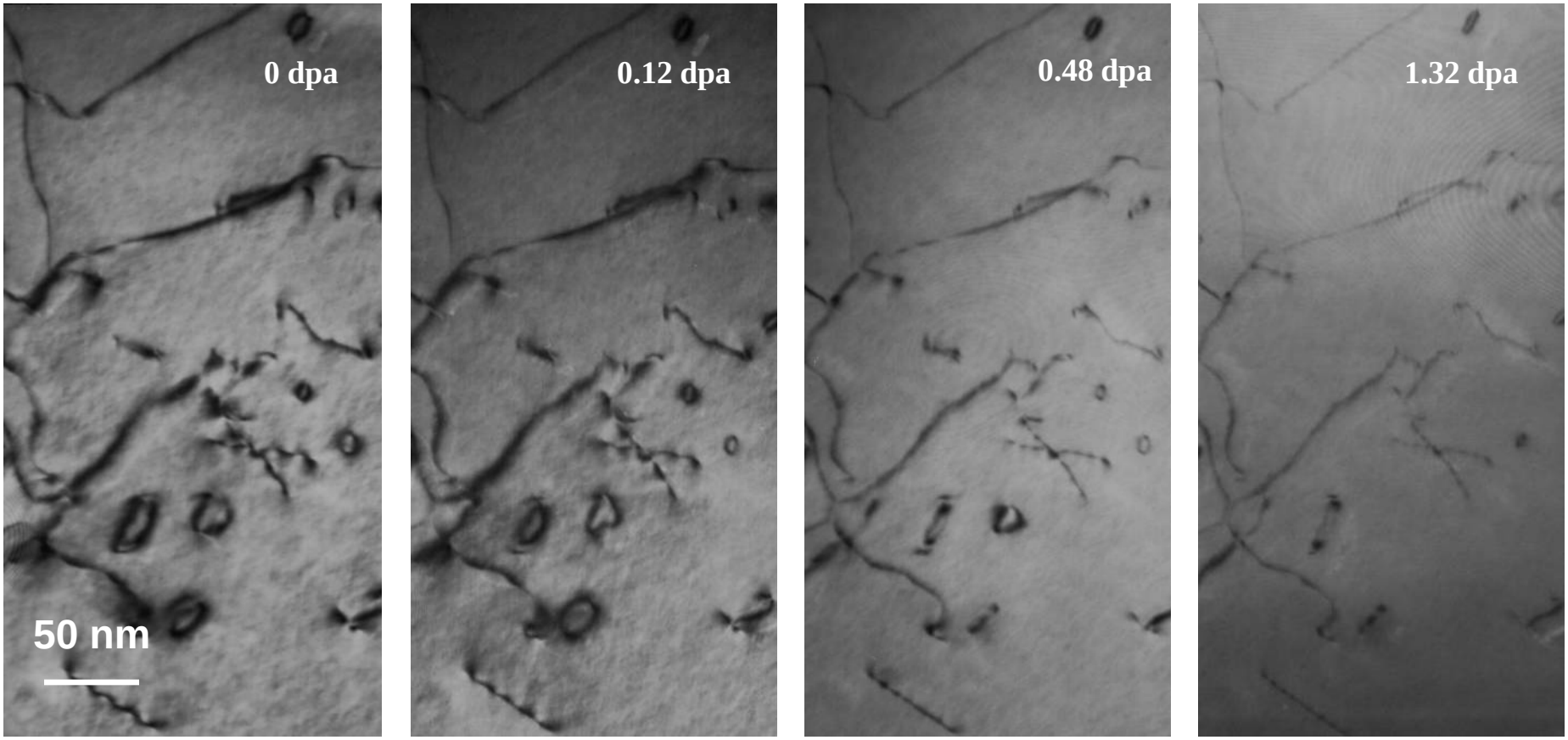


133min



0 dpa **0.01 dpa** **0.06 dpa** **0.1 dpa** **0.45 dpa**

Change of loops during electron irradiation at 773 K after H^+ implantation



0 dpa **0.12 dpa** **0.48 dpa** **1.32 dpa**

Change of loops during electron irradiation at 823 K after D^+ implantation

Summary

- Adding a little silicon may improve the swelling resistance of ferritic / martensitic steels.
- The vacancy loops could formed in the iron implanted with hydrogen ions or with deuterium ions after annealing.
- Such vacancy loops may shrink during electron irradiation.
- The shrinkage rate of the vacancy loops with hydrogen ions is higher than with deuterium ions.
- So the loops with hydrogen ions have a larger bias strength as sink to point defects than the loops with deuterium ions.
- Maybe the loops with tritium ions have the weakest bias strength among the three hydrogen isotope atoms.

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