大型放射光施設SPring-8を用いた材料の局所ひずみ・応力解析

(公財)高輝度光科学研究センター 産業利用推進室
○梶原堅太郎、橋本保、佐藤眞直

(株)原子力安全システム研究所
山田卓陽、寺地巧、福村卓也、有岡孝司

東京工業大学
宮澤知孝

IGSCC

冷間加工度

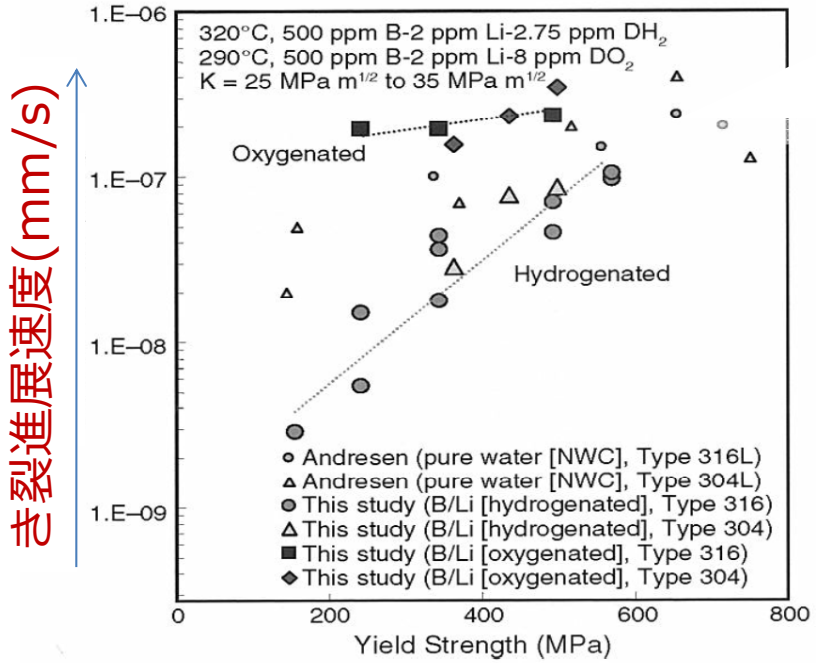
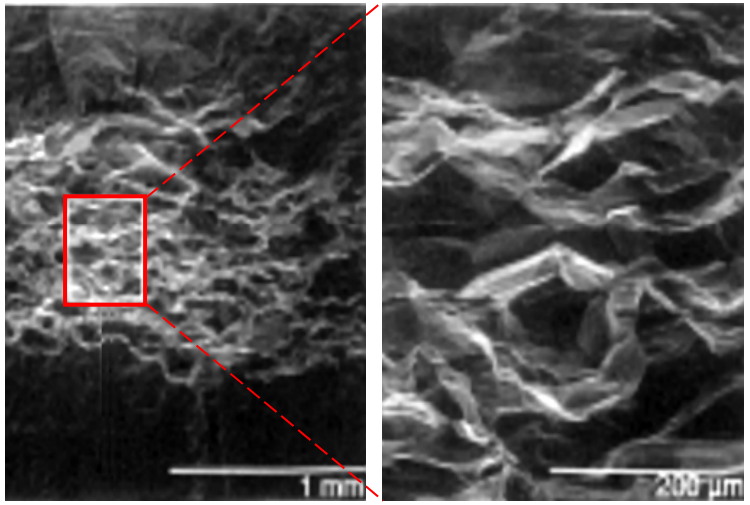


FIGURE 5. *Crack growth rate vs. yield strength for specimens exposed to hydrogenated and oxygenated water environments.*

Ref.: K.Arioka, T.Yamada, T.Terachi, G. Chiba, Corrosion,2007, Vol.63, No.12, p.1114



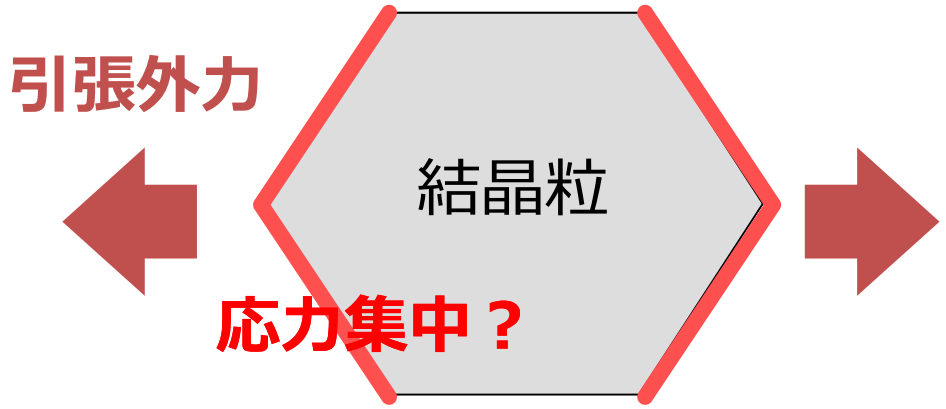
20%CW316のSCC破面(粒界型)

強い冷間加工を加えたステンレス鋼は、非鋭敏化状態であっても、高温水中で粒界型のSCC進展を示す。

目的

ステンレス鋼の粒界型SCC機構解明

冷間加工による結晶粒界近傍の応力集中？



引張外力を印加したしたときのひずみ分布を測定することで応力集中を評価

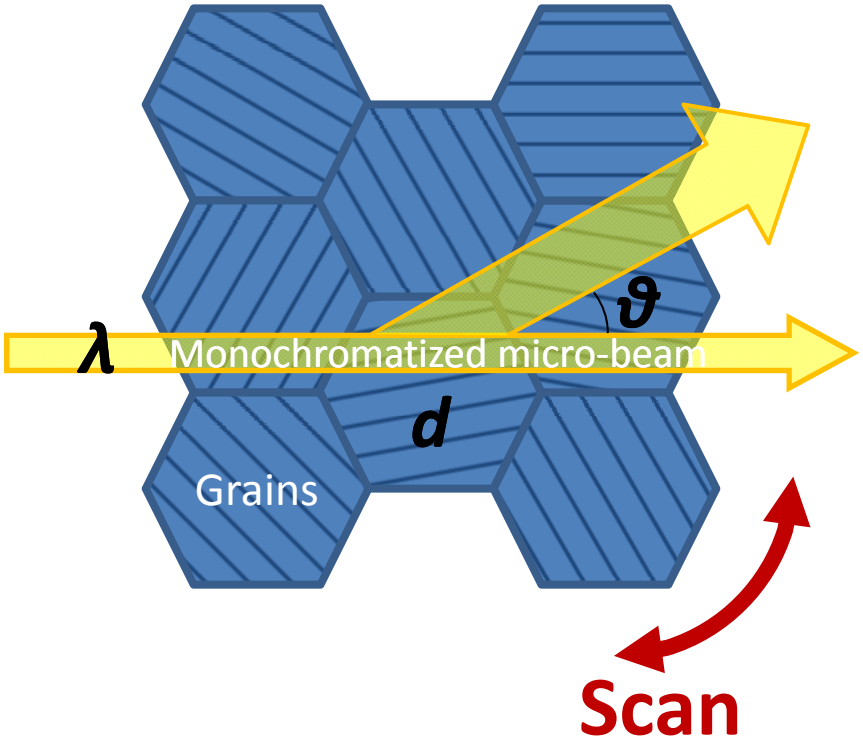
What Kind of Probe Should We Use?

- ~~Electron~~ *Only surface*
- ~~Neutron~~ *Low brilliance*
- X-ray
  - ~~Laboratory source~~ *Low brilliance*
  - Synchrotron source *High brilliance* *High energy*
    - Monochromatic
    - **White**

Why Did We Use White X-rays?

$$2d \sin \vartheta = \lambda$$

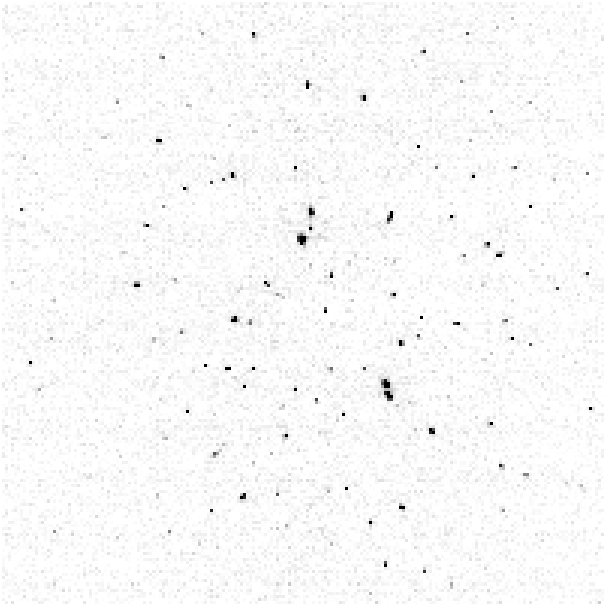
Monochromatized X-rays



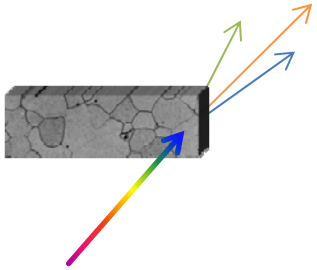
Bragg conditions are automatically fulfilled by white X-rays

Advantage of White X-rays

X-ray signals of all grains are detectable



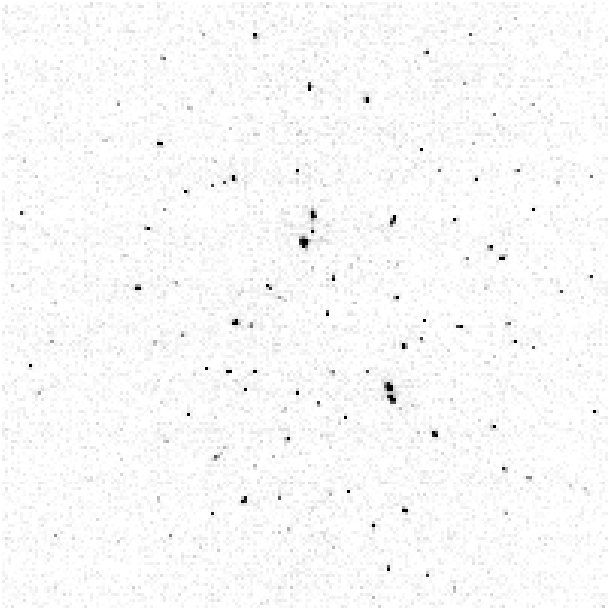
Diffraction pattern



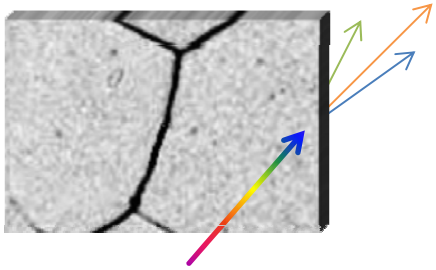
White X-ray micro-beam

Advantage of White X-rays 2

Grain boundary visualization



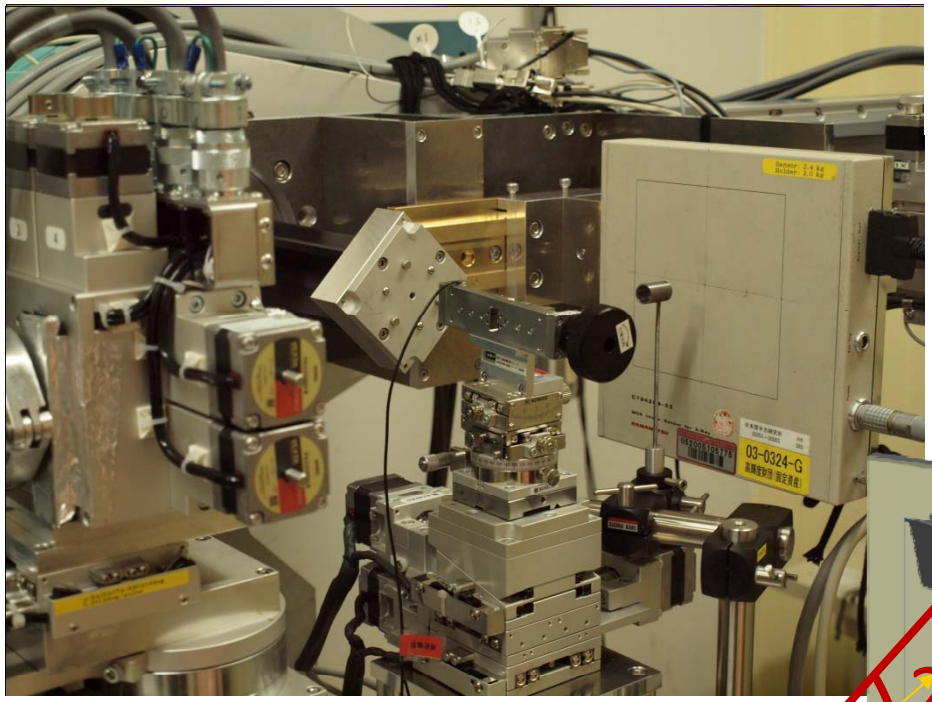
Diffraction pattern



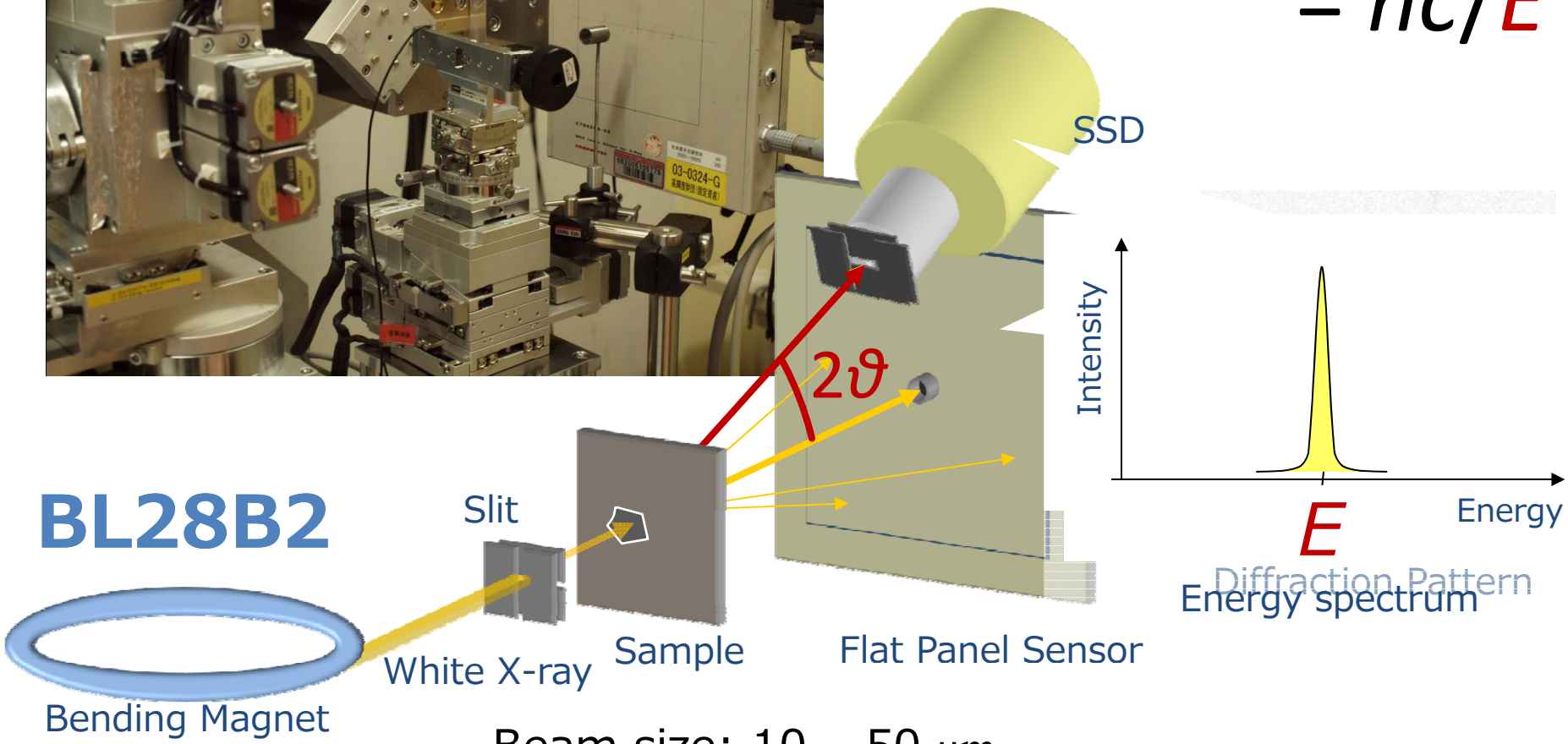
White X-ray micro-beam

Instrumental Layout of **EXDM**

(Energy Dispersive X-ray Diffraction Microscopy)

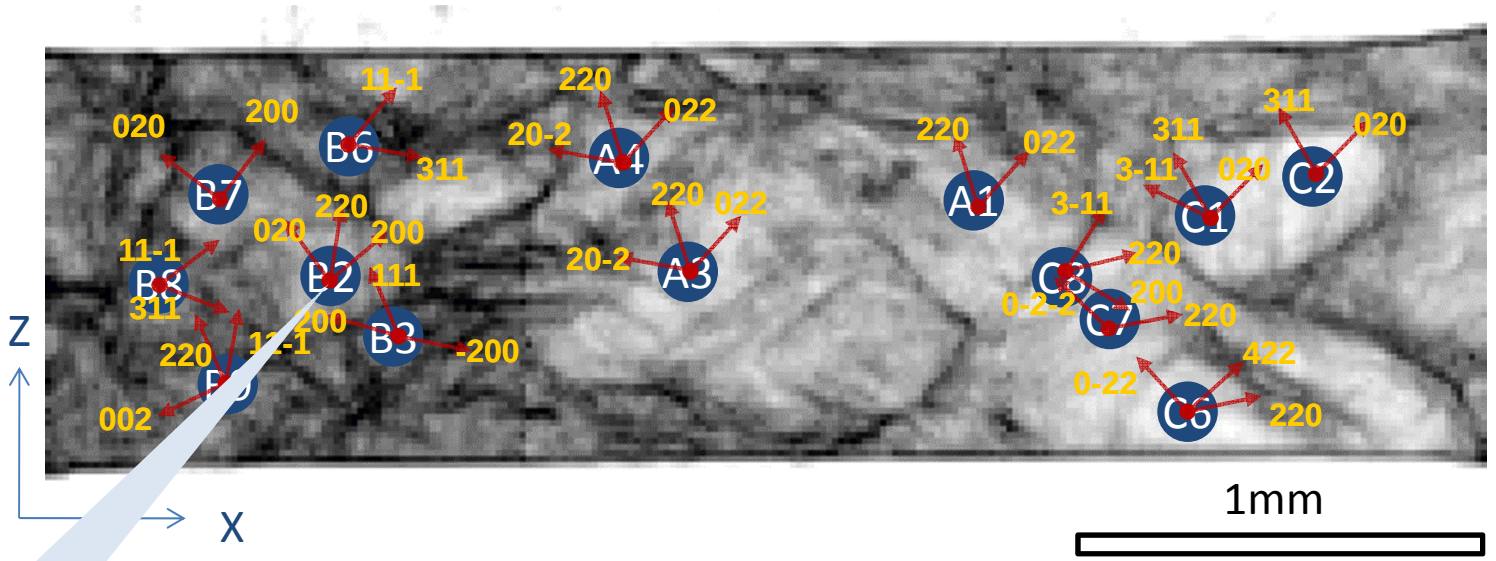


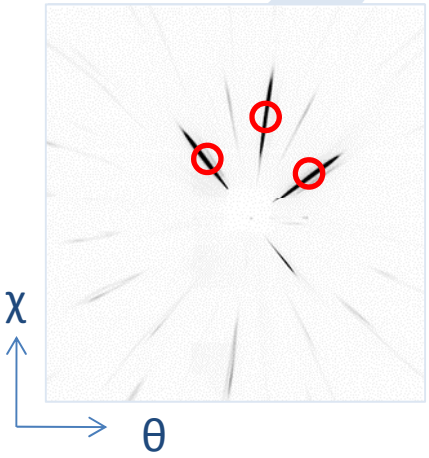
$$2d \sin \vartheta = \lambda = hc/E$$



Beam size: 10 – 50 μm

測定手順





重心位置テーブル化

X [mm]	Z [mm]	χ [deg]	θ [deg]
54	42	11.37	-1.81
		6.57	4.84
		5.00	-6.95

λ測定へ

Lattice Spacing, Elastic-Strain and Stress

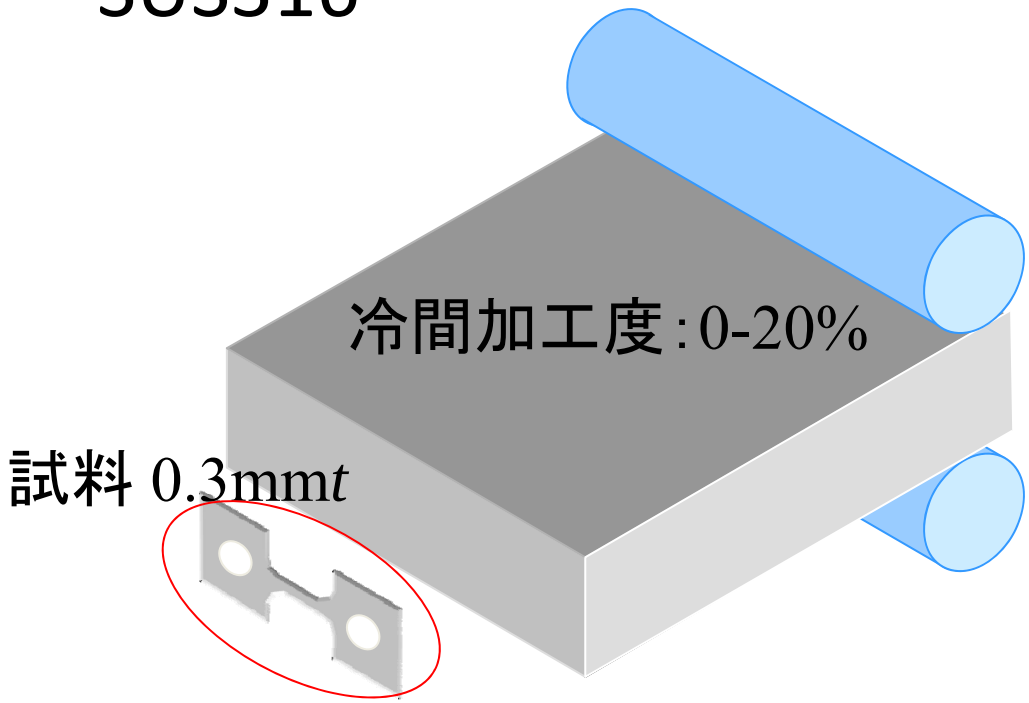
Lattice spacing : $$d = \frac{\lambda}{2\sin\theta}$$ (Bragg's law)

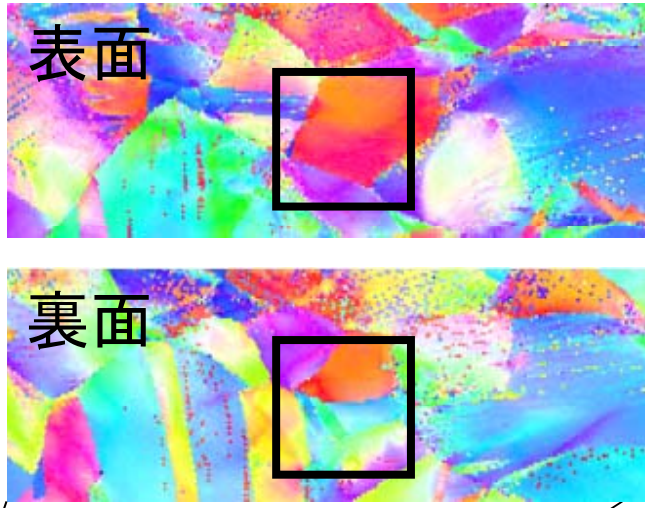
Elastic-strain : $$\varepsilon = \frac{d - d_0}{d_0}$$

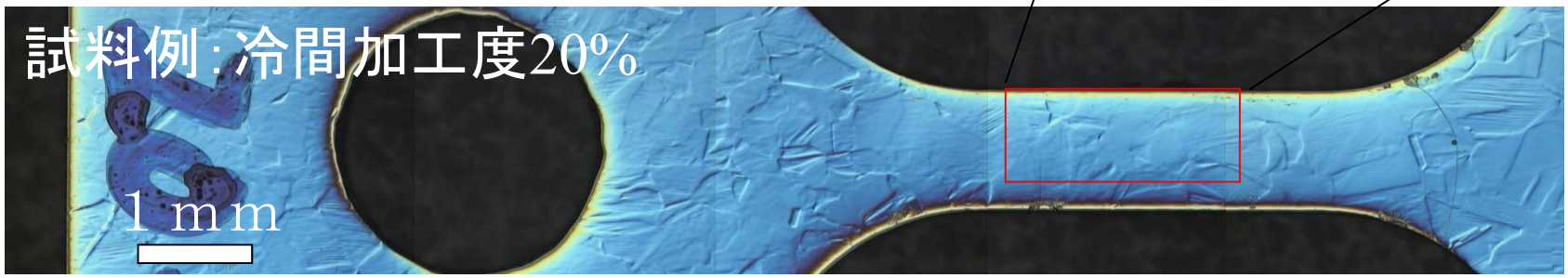
Stress: $$\boldsymbol{\sigma} = \mathbf{C}\boldsymbol{\varepsilon}$$ (Hooke's law)

試料

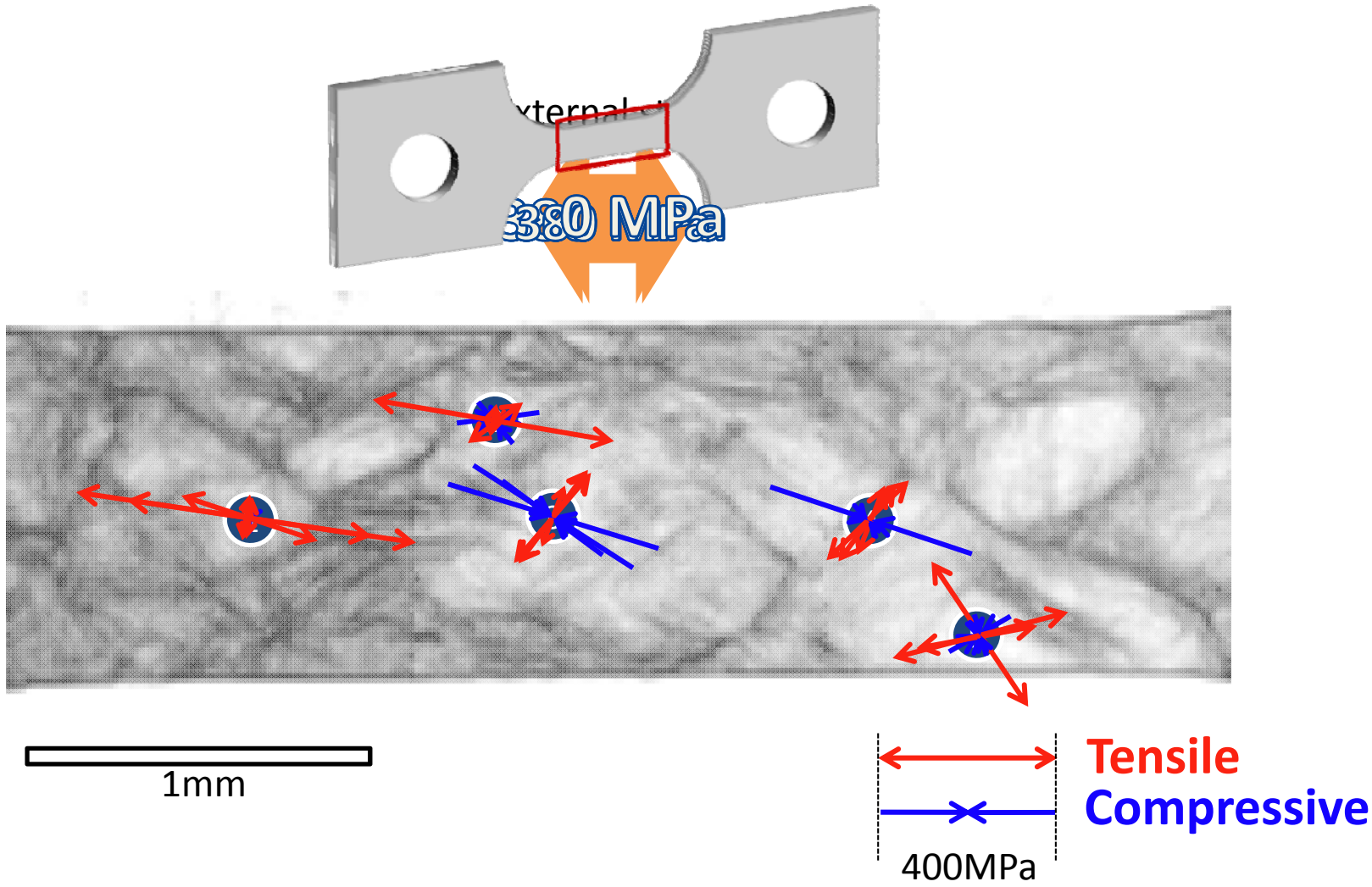
- SUS316





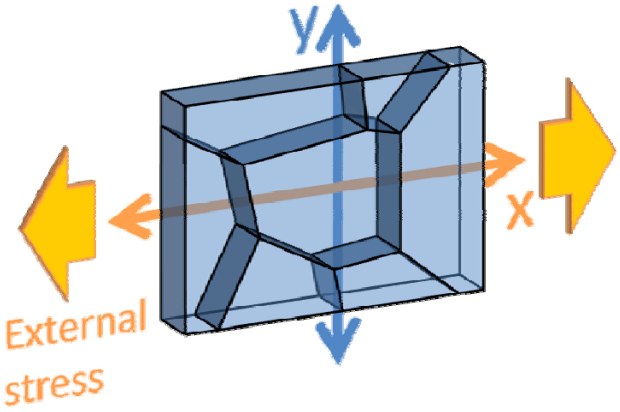


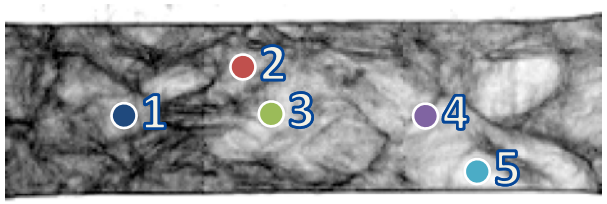
Distribution of Principle Stress

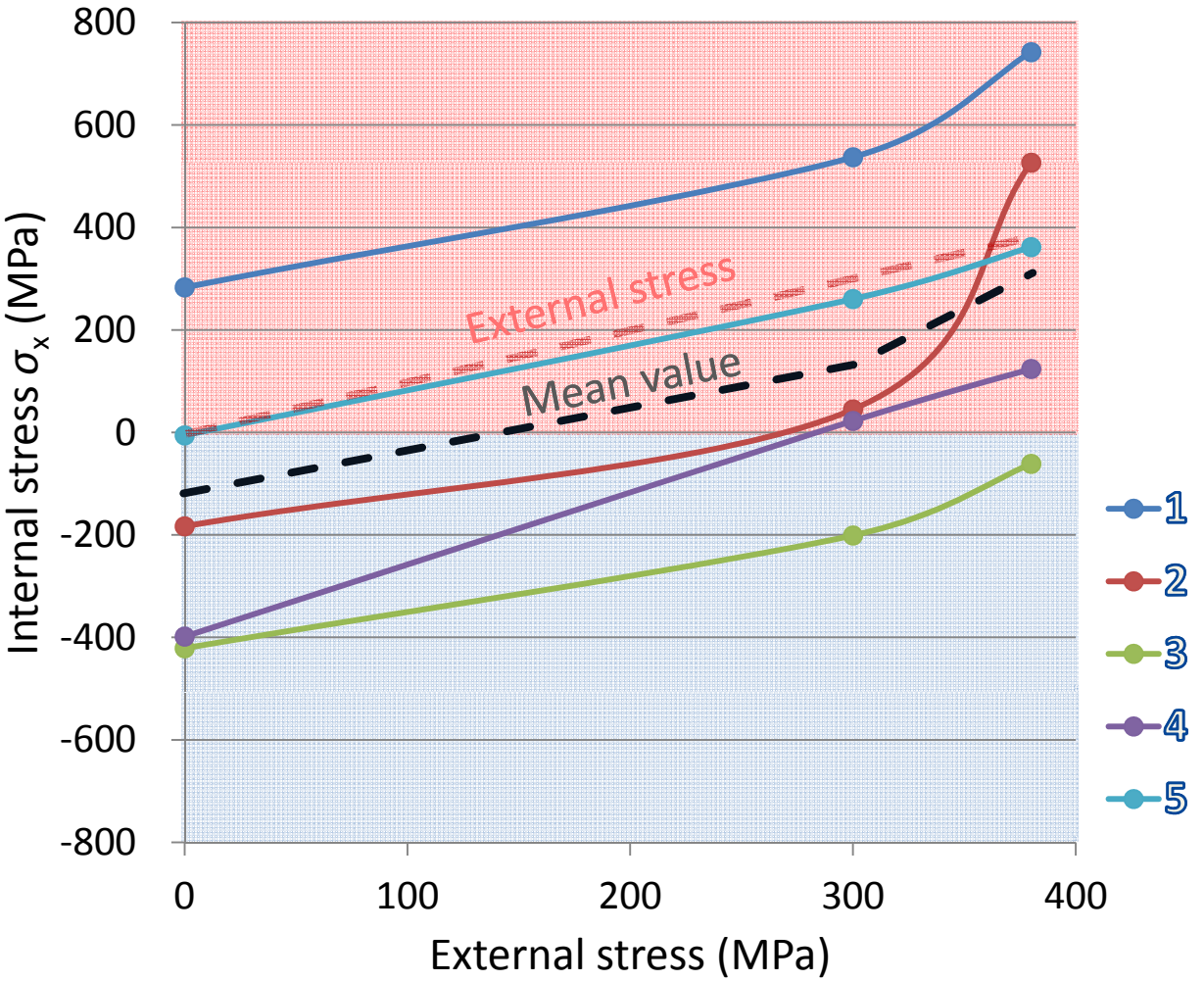


σ_x vs. External Stress

Quantitative evaluation

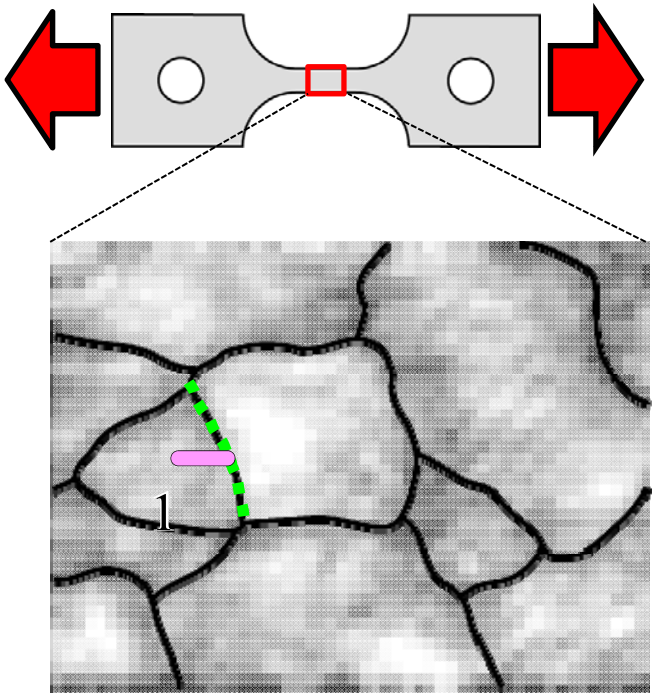


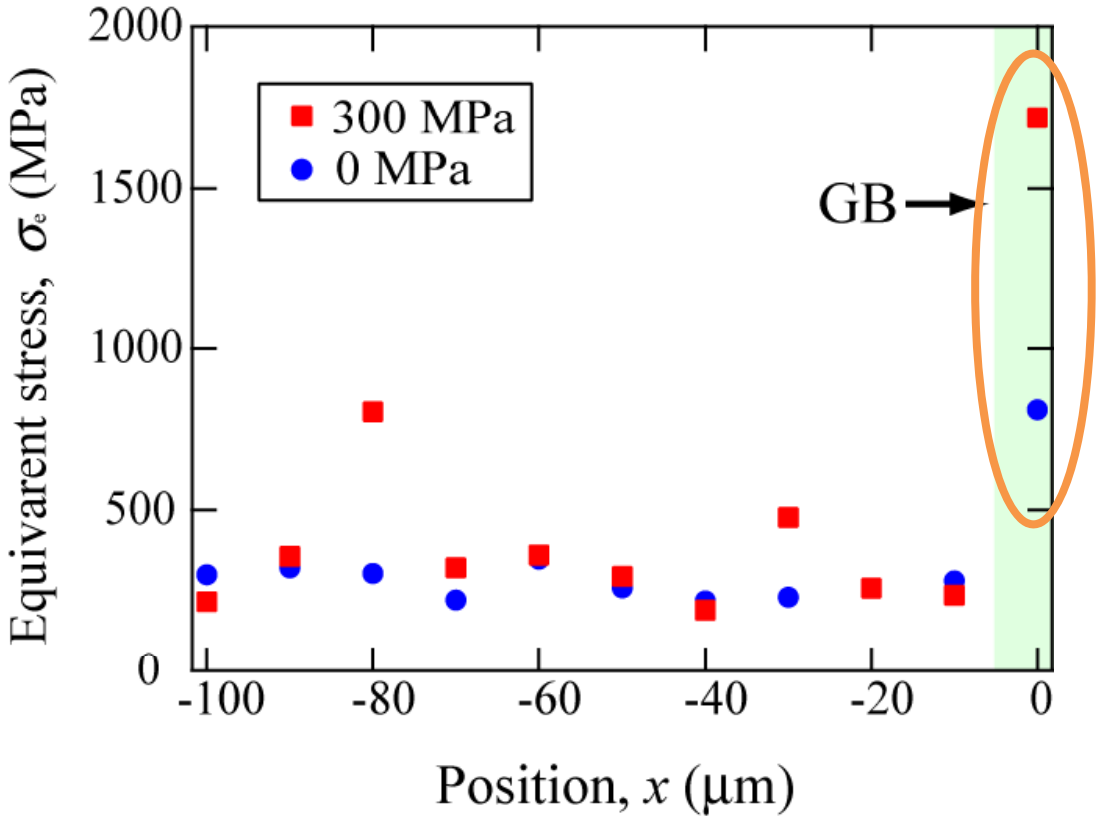




実験結果・2

SUS316 20%冷間圧延材　結晶粒界近傍の局所応力分布





まとめ

- 目的:ステンレス鋼の粒界型SCC機構解明
  - 粒界に応力集中があるのか実験で確認
- そのための手法開発
  - 放射光白色X線を用いた結晶粒内応力測定技術
    (EXDM Energy Dispersive X-ray Diffraction Microscopy)

kajiwara@spring8.or.jp