

放射光時間分解X線回折測定による 光記録媒体の相変化構造計測

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独立行政法人理化学研究所・播磨研究所 放射光科学総合研究センター
JST-CREST

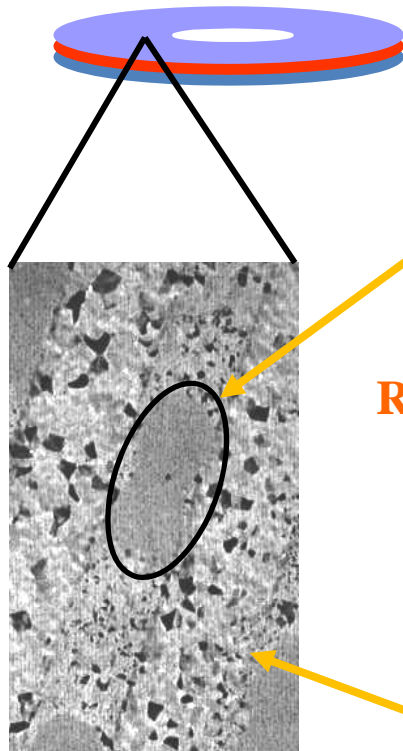
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1. はじめに
 - ・DVD材料における高速相変化
 - ・XRDで構造変化をみる
 2. 時間分解測定法の開発
 - ・放射光の時間構造と手法
 - ・時間分解X線回折測定技術
 3. 観察結果
 - ・反射率変化と相変化の関係
 - ・GST, AISTにおける結晶成長の相違
 4. まとめ
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1. はじめに

1.1 DVD材料における高速相変化

GST225 ($\text{Ge}_2\text{Sb}_2\text{Te}_5$)

AIST ($\text{Ag}_{3.5}\text{In}_{3.8}\text{Sb}_{75.0}\text{Te}_{17.7}$ (%))

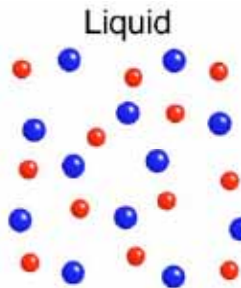


Recorded mark

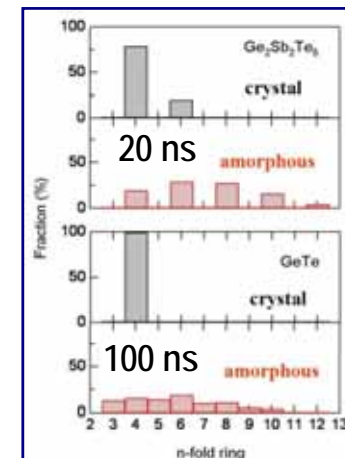
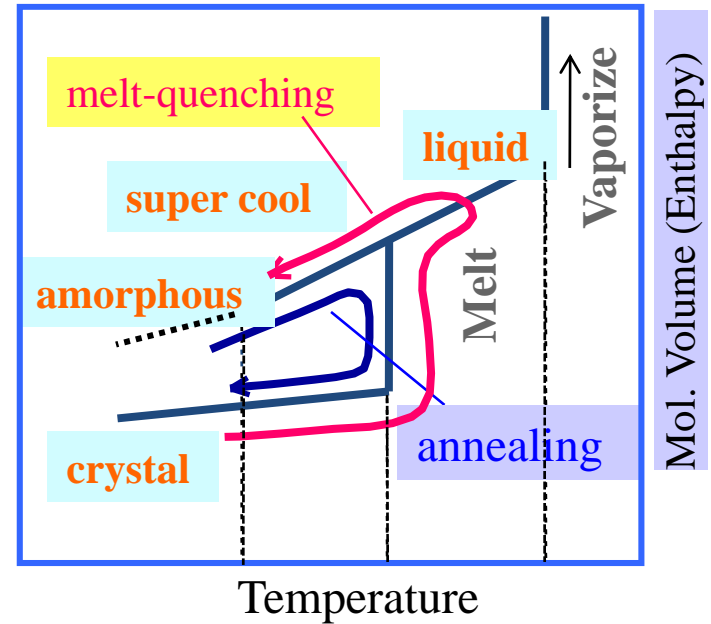
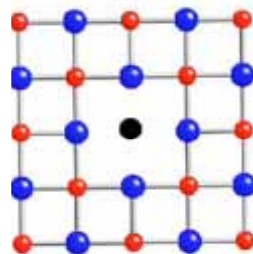
20-30 ns Erasing



Writing



Crystal

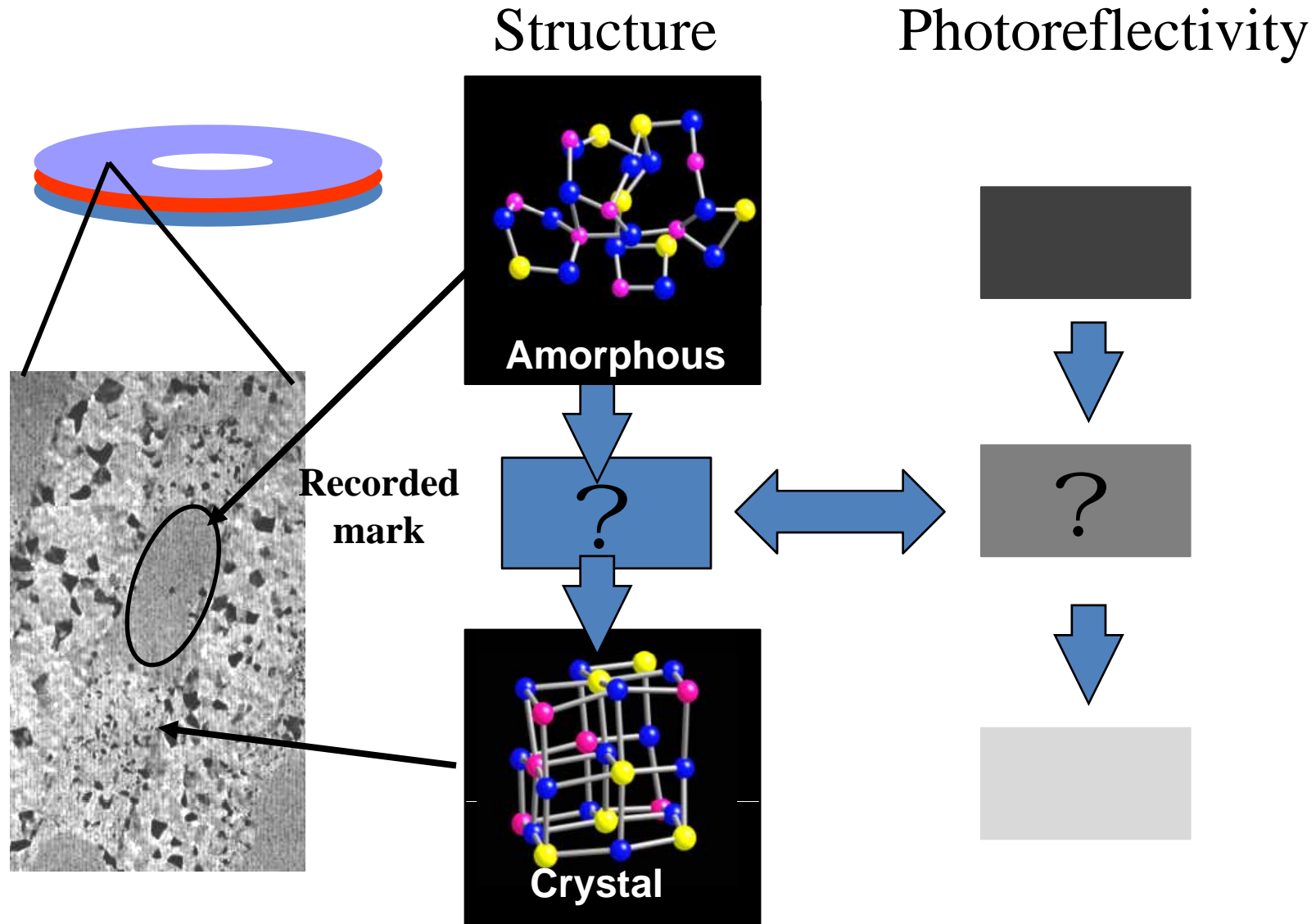


S. Kohara et al. : Appl. Phys. Lett. 89, 201910 (2006)

記録マークのサイズ: $0.32 \mu\text{m}$
書込・消去の速度: 20 ~ 30 ns

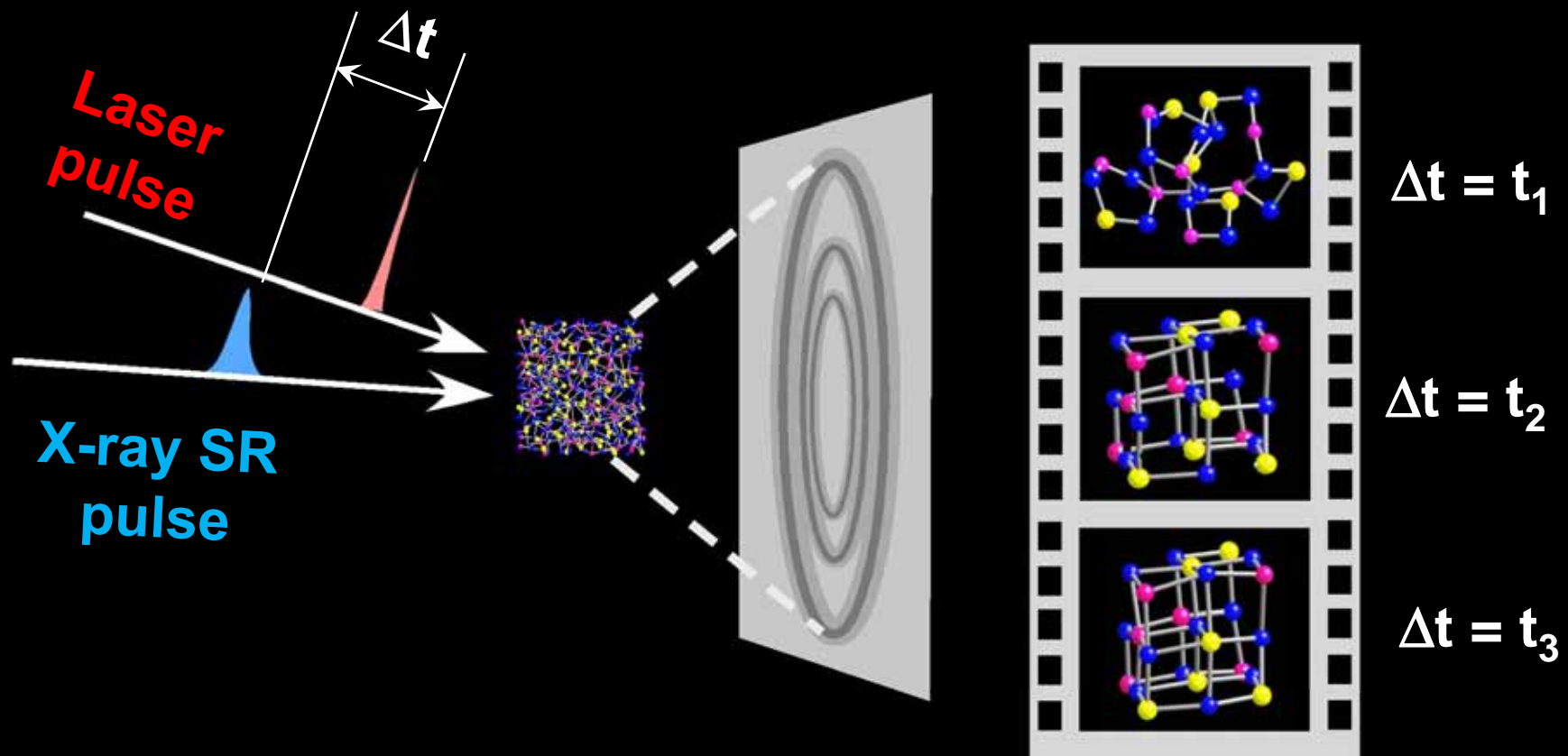
相変化速度とアモルファスのリング構造の相関

反射率と構造の関係？



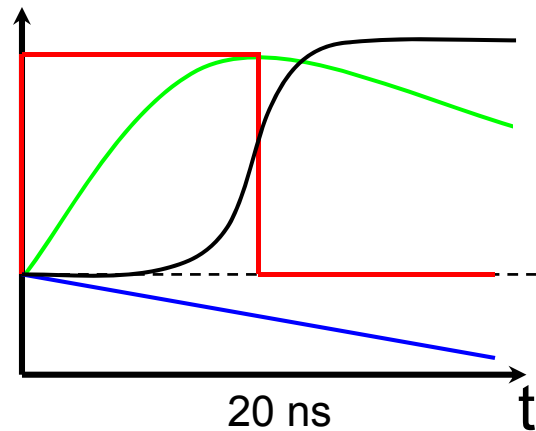
1.2 XRDで構造変化をみる

Time-resolved X-ray diffraction (Laser pump-X-ray SR probe)

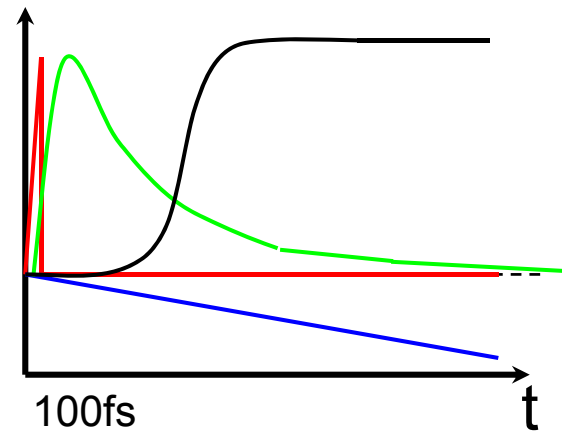


インパルス応答を調べる

Commercial DVD media



Impulse response



- Laser irradiation
- Thermal diffusion
- Temperature
- Diffraction Intensity

**フェムト秒パルスレーザー
による刺激**

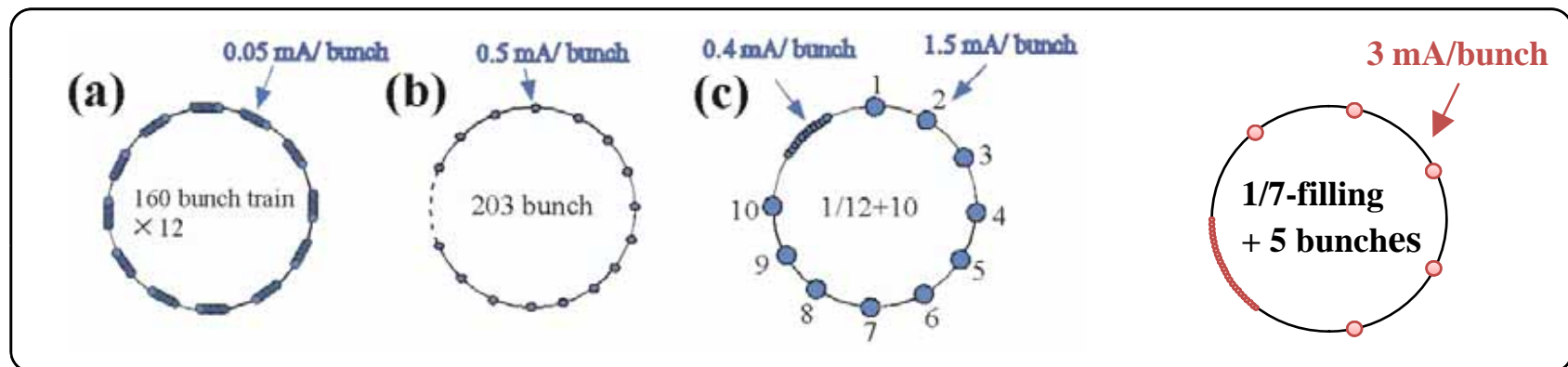
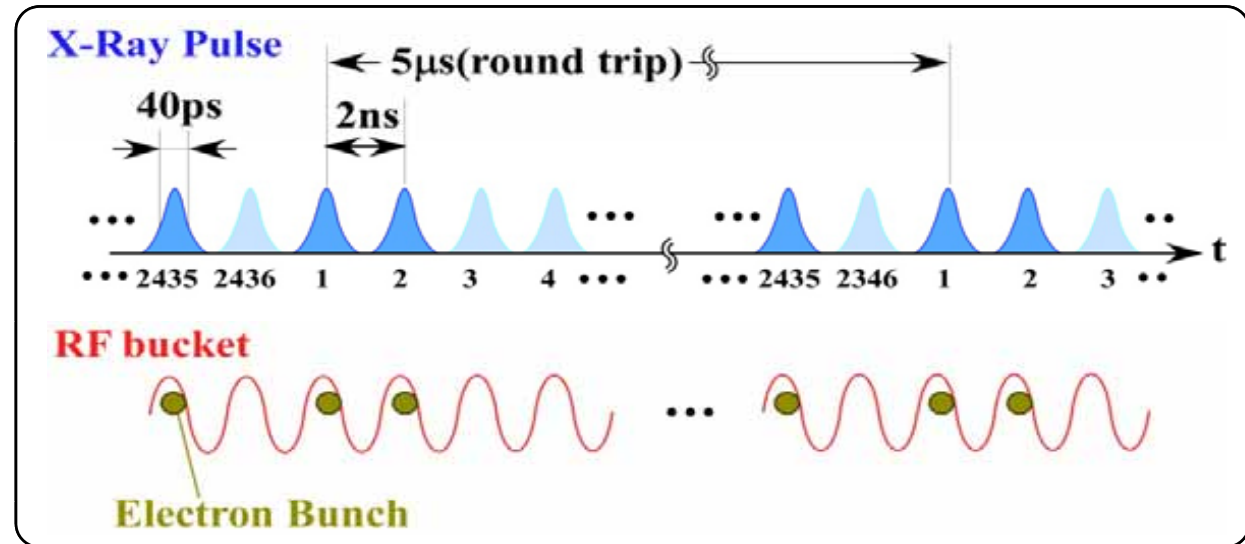
2. 時間分解測定法の開発

2.1. 放射光の時間構造と手法

蓄積リング放射光の時間構造



Pulse width:
40 ps (FWHM)
Rep. rate:
200 kHz-509MHz

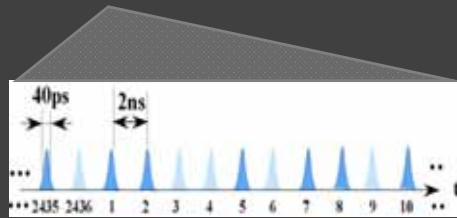
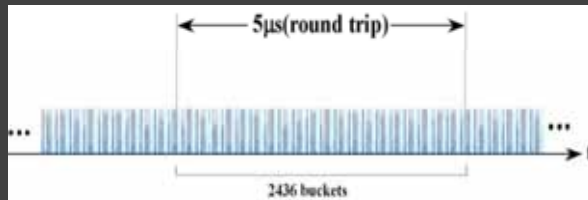


2.2. 時間分解X線回折測定技術

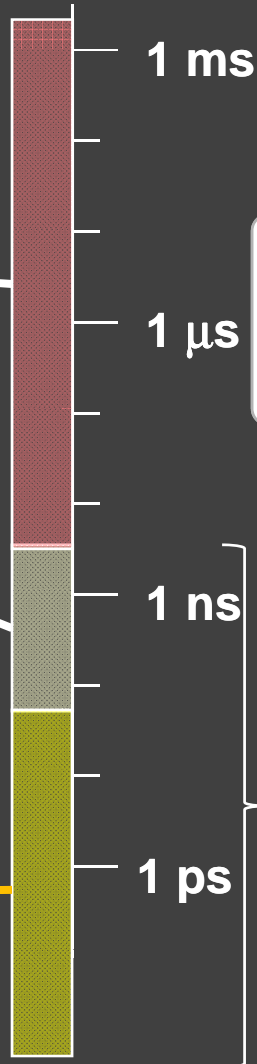
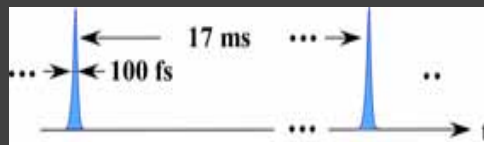
SR の時間構造

時間分解能と手法

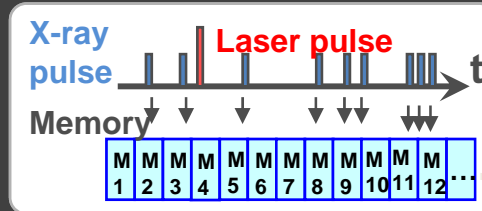
Storage Ring



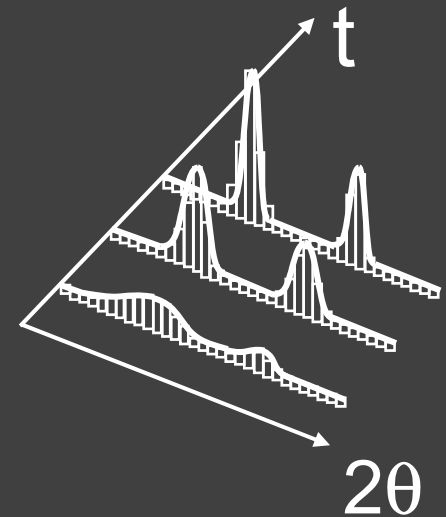
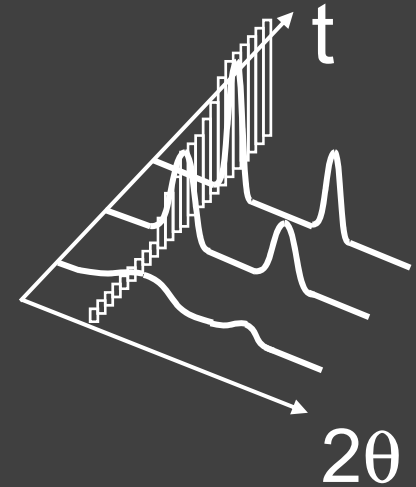
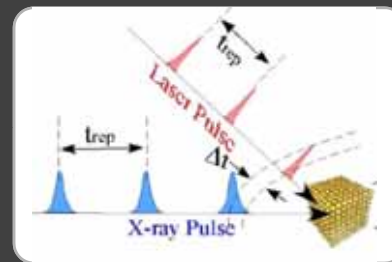
XFEL



APD+MCS



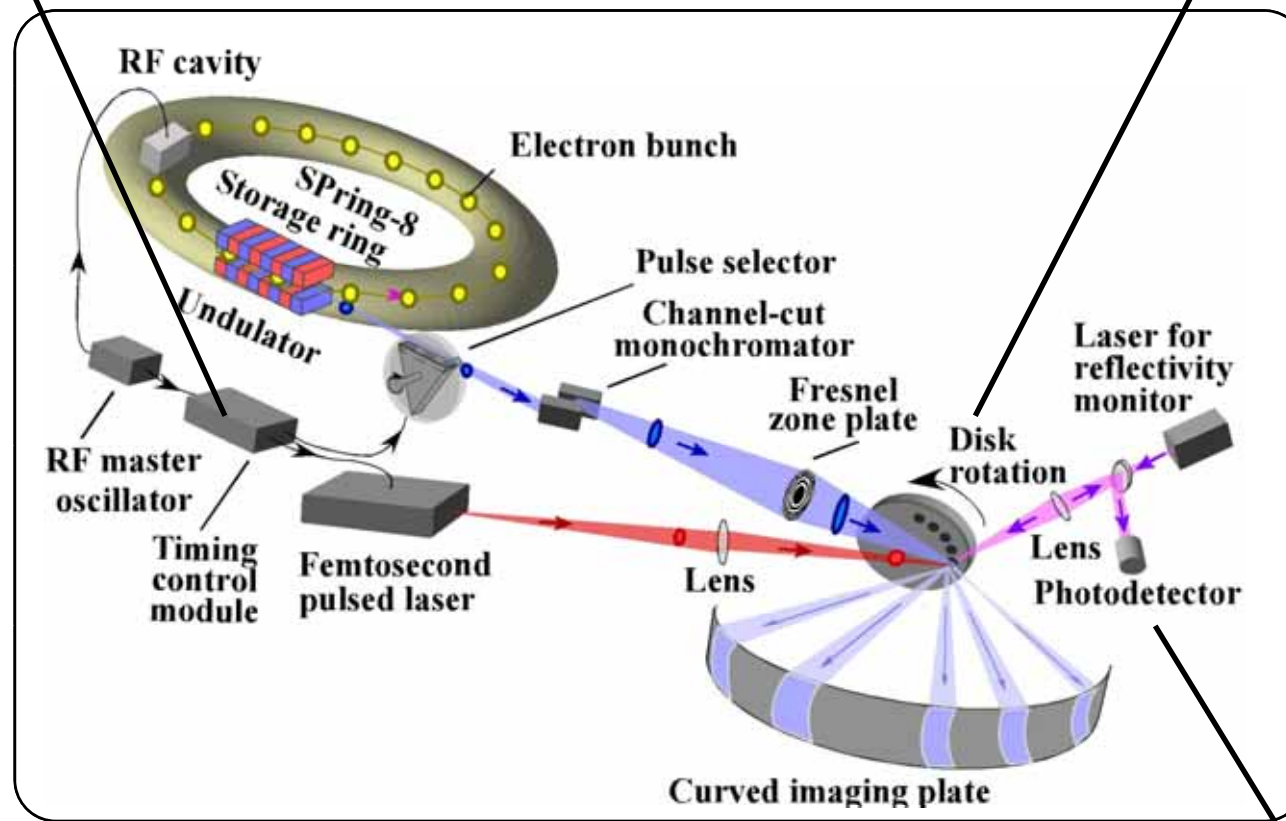
Pump-probe



要素技術

(1) Timing control between SR and laser pulses

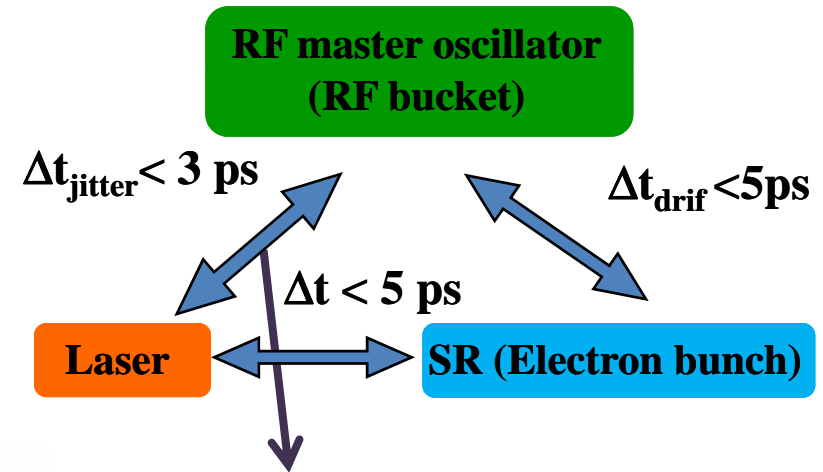
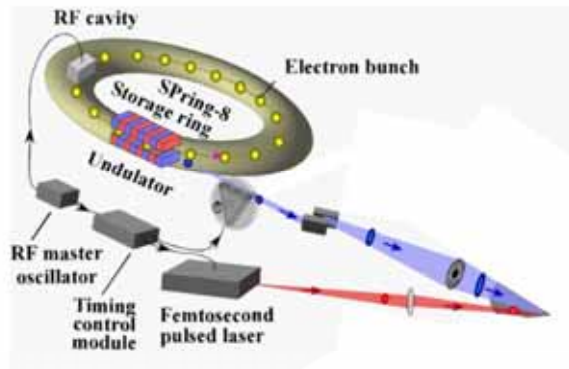
(2) Sample rotation stage for phase-change materials



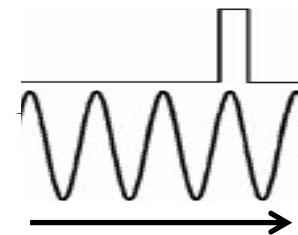
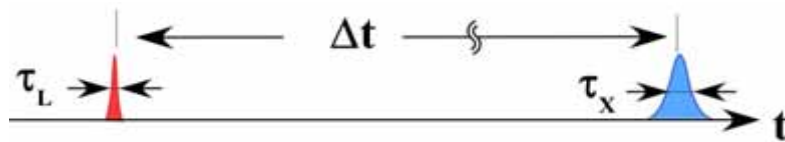
(3) On-line monitor of photorefectivity

(1) Timing control between SR and laser pulses

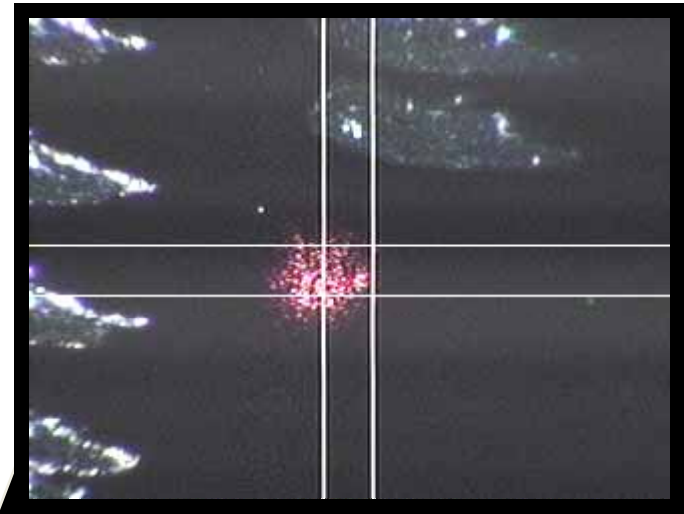
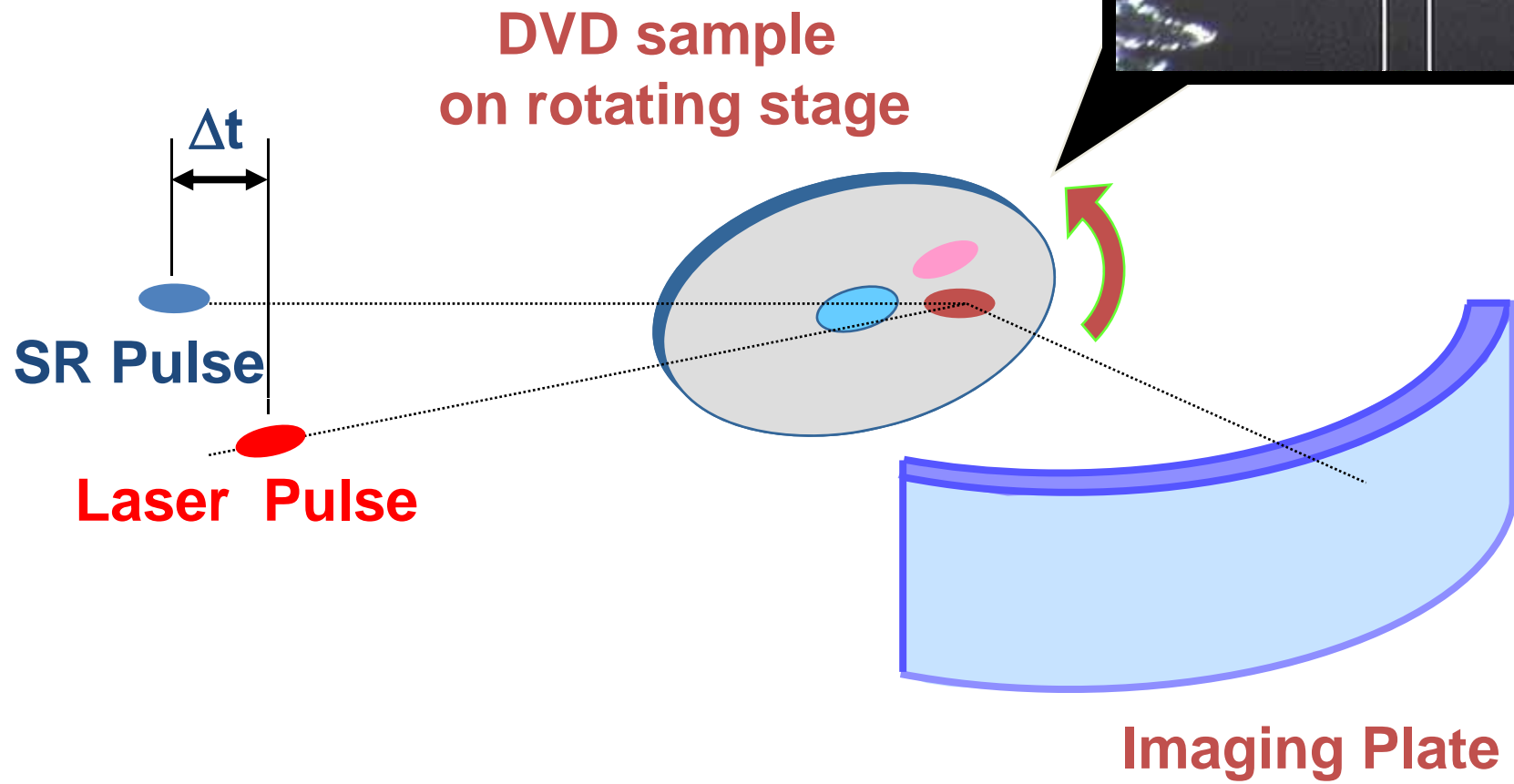
(i) Synchronization of laser and SR



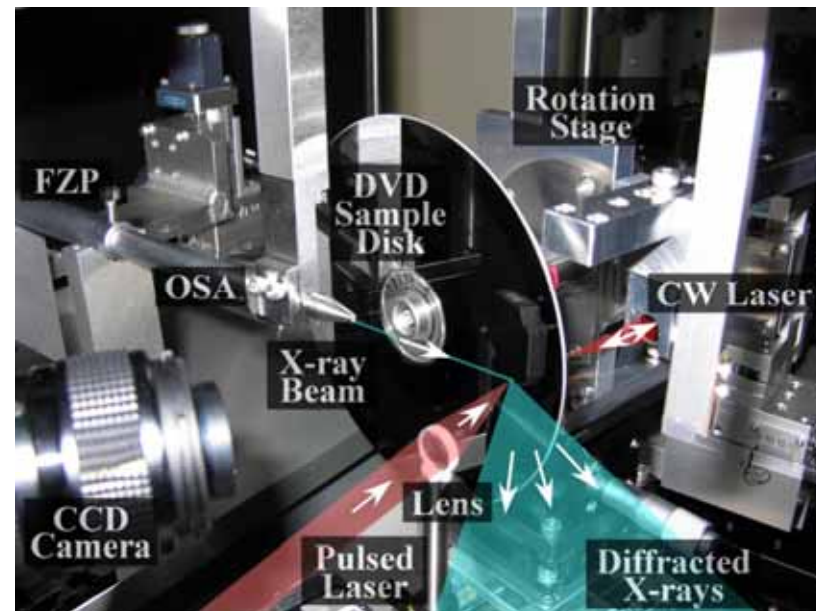
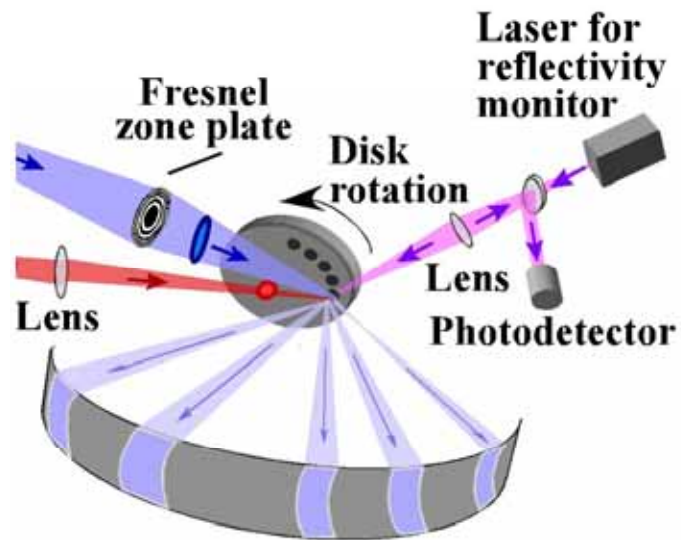
(ii) Time delay control



(2) Sample rotating system



(3) On-line monitor of photorefectivity

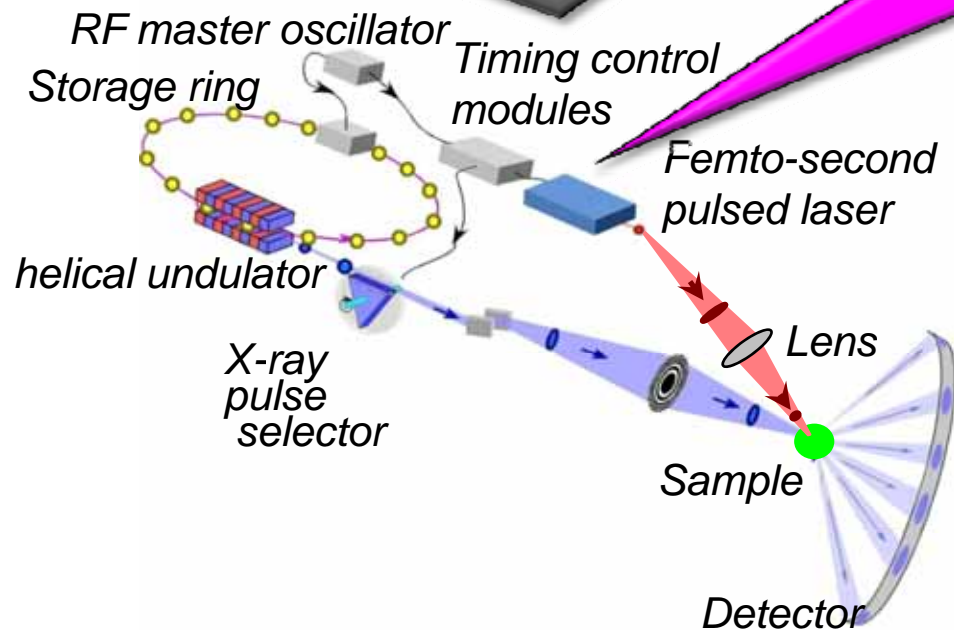


Picosecond TR-XRD system

Timing control circuit



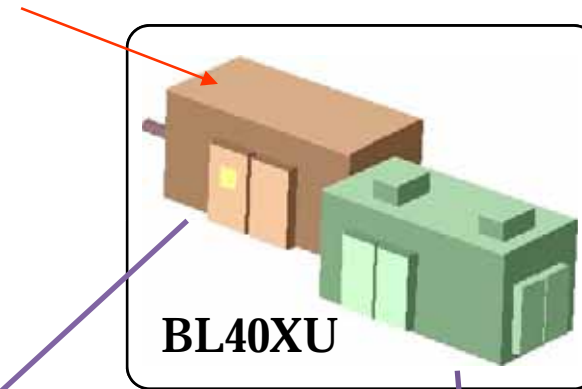
Femto- pico-second laser system



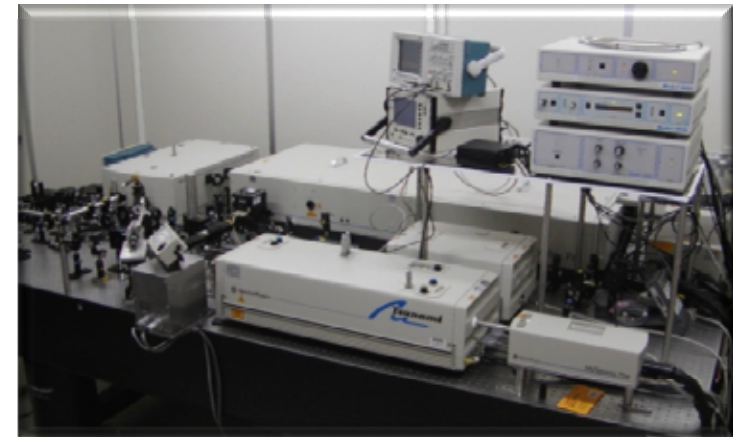
Diffractometer



Time-resolved diffraction station in BL40XU

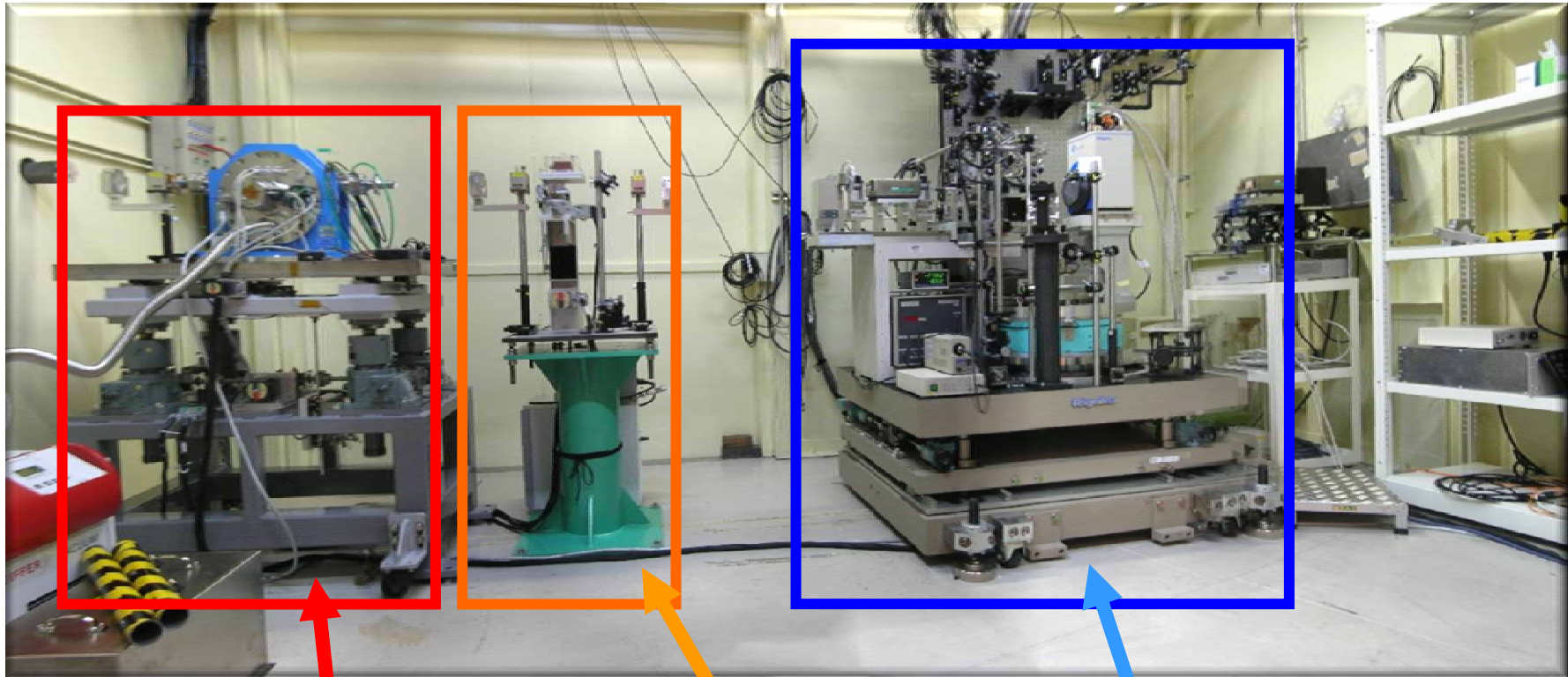


X-ray exp. hutch



Laser booth

X-ray experimental hutch@ SPring-8 BL40XU



X-ray Pulse Selector (XPS)

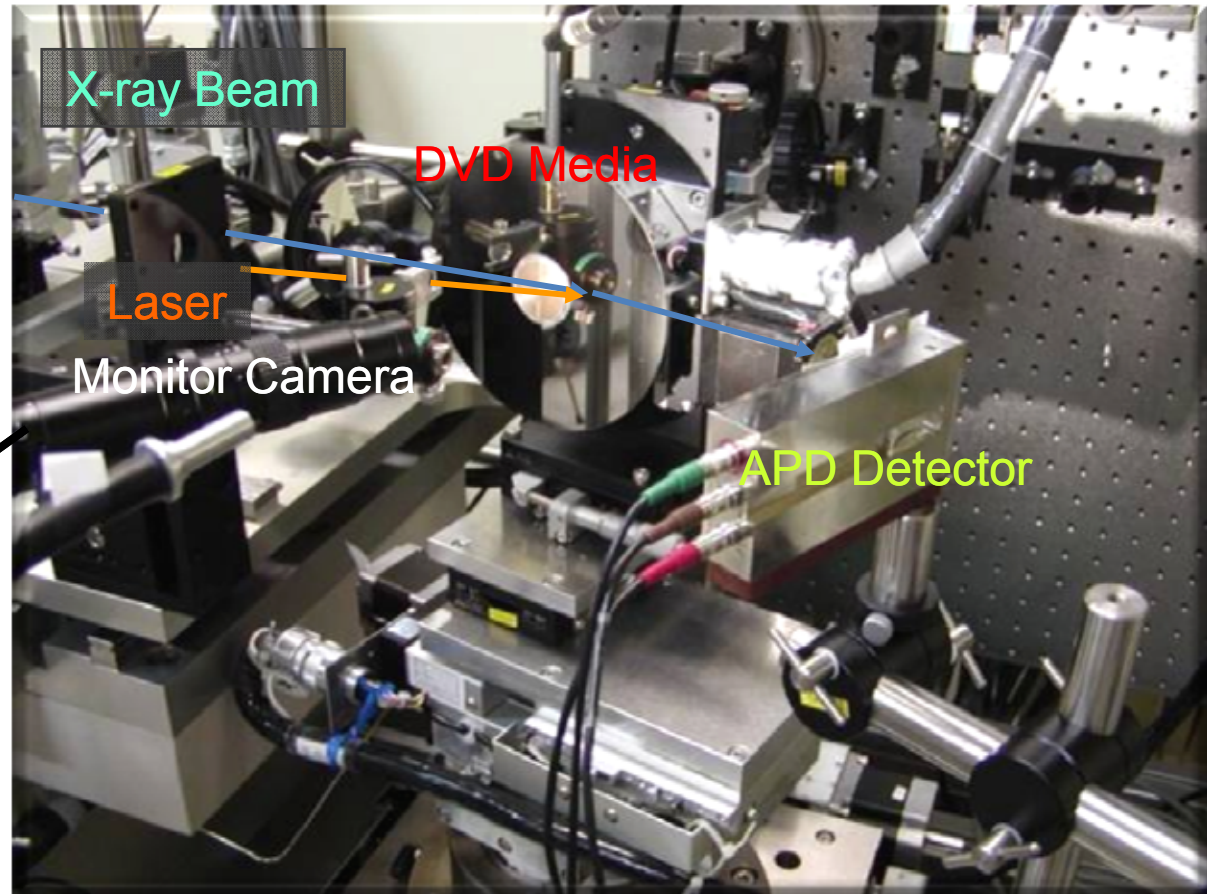
Si(111) Channel-cut Monochromator

Precise Diffractometer System

DVD Phase Change Time Resolved X-ray Measurement System

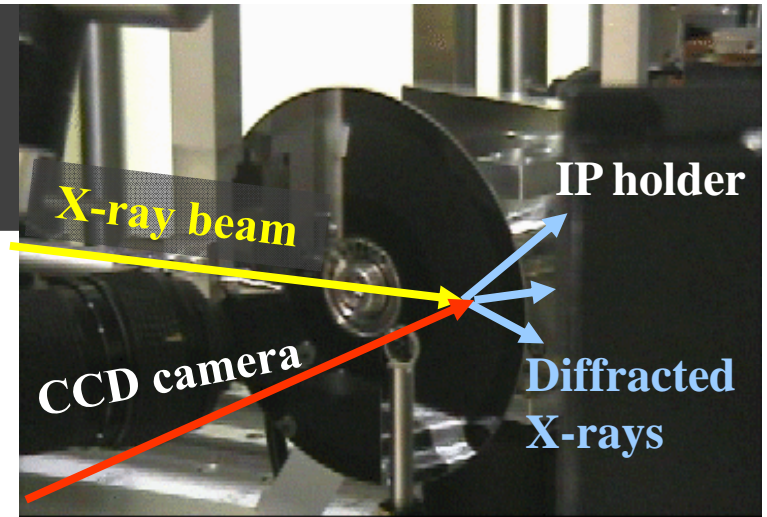


Single Shot Controller

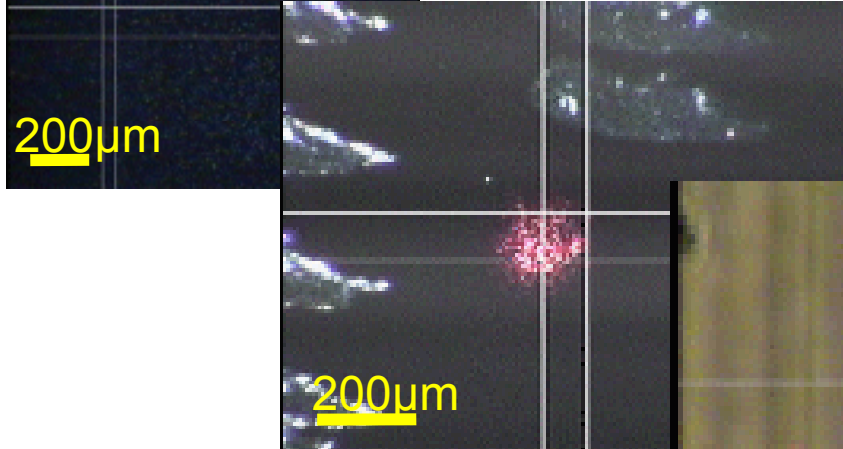


Sample Monitor

DVD材料測定用高速回転試料台

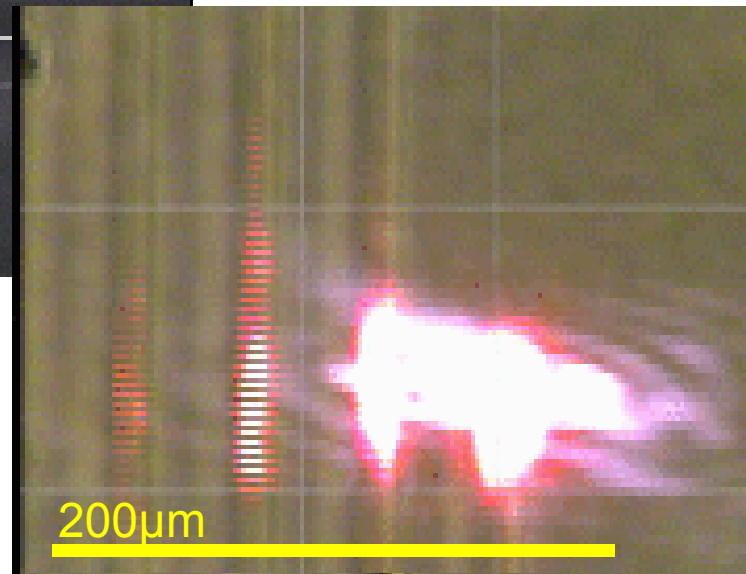


Nov. 2006
Repetition rate 1 Hz

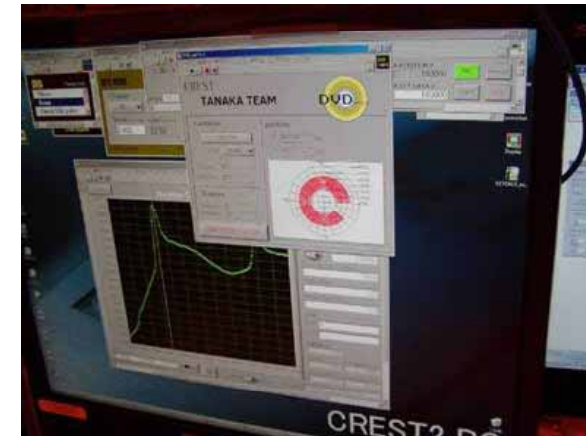
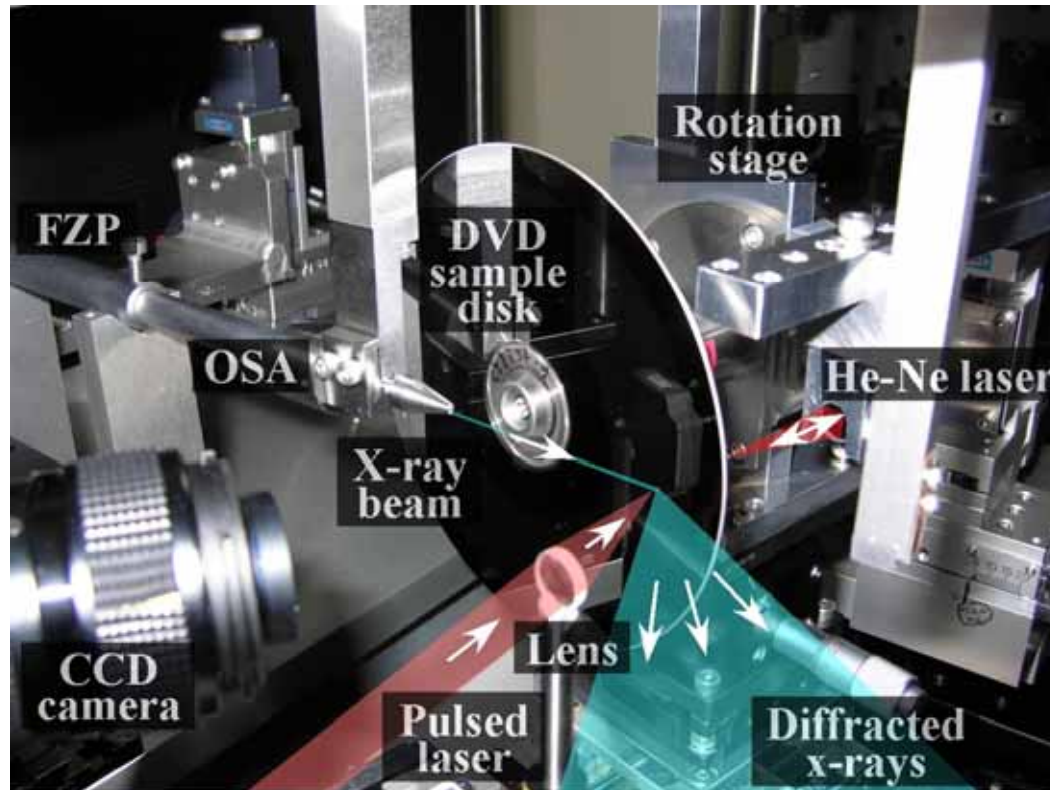


April 2007
Repetition rate 5 Hz

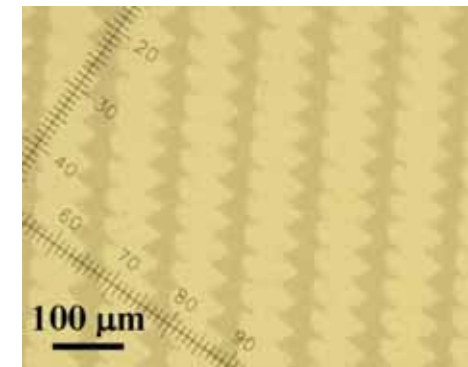
April 2008
Repetition rate 1 kHz
Using X-ray microbeam



DVD相変化材料測定用 時分割マイクロビームX線回折システム



LabVIEWによる制御画面

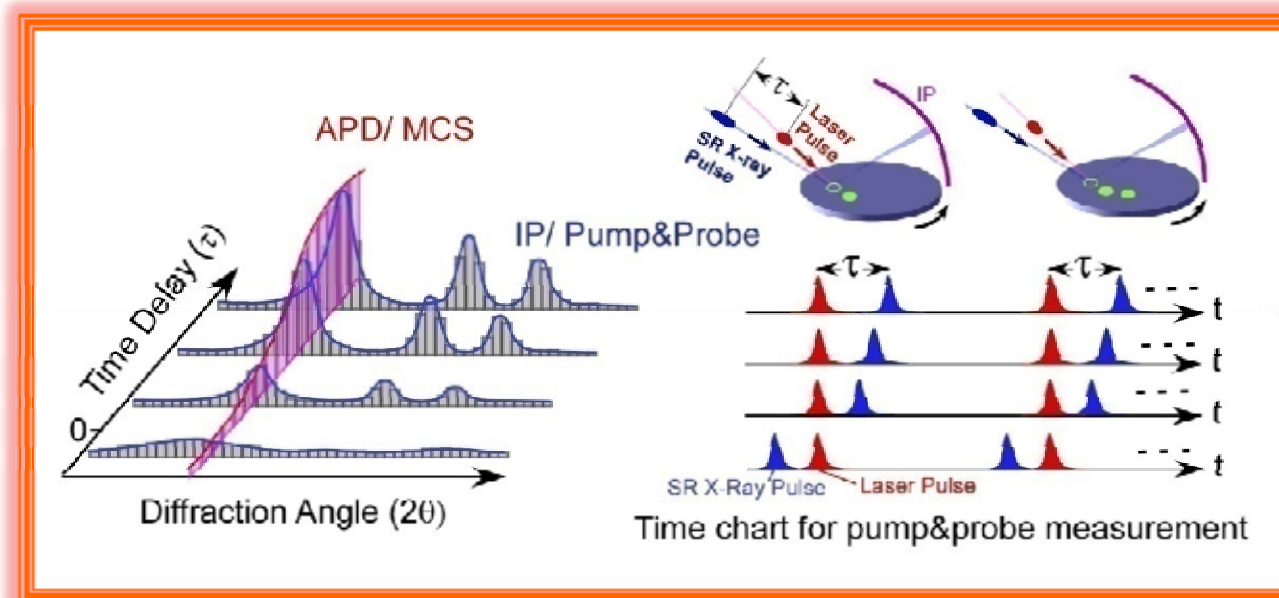
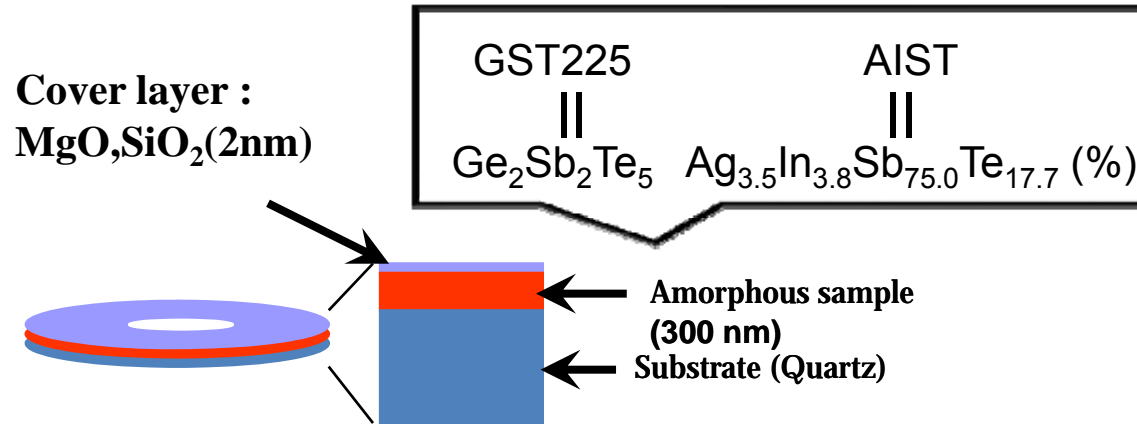


試料表面

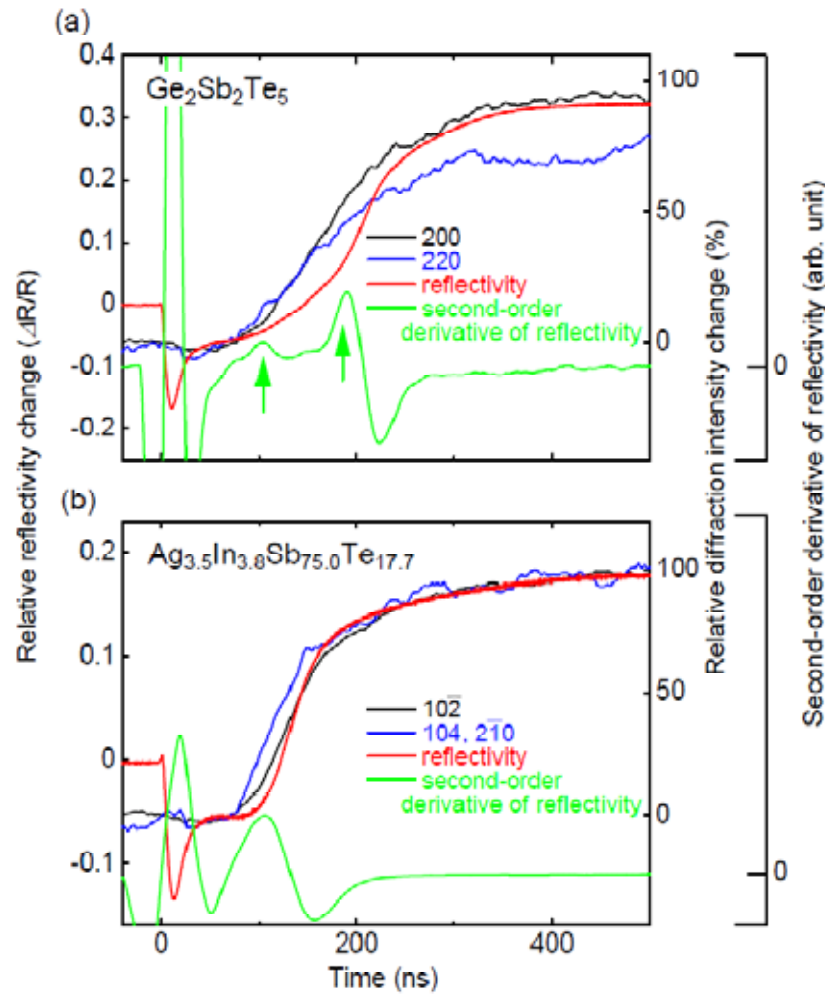
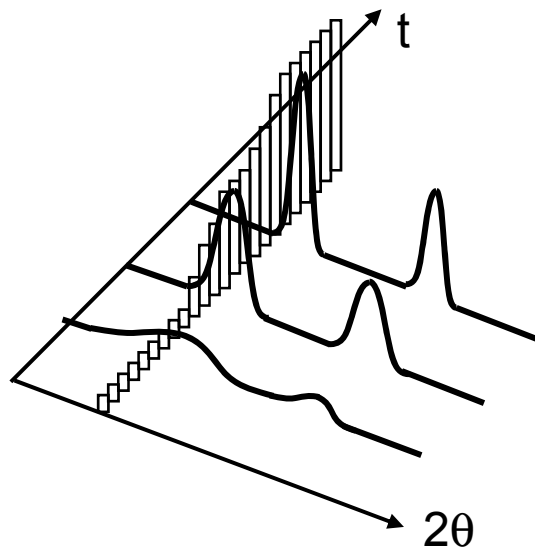
繰り返し周期 t_{rep}	移動速度 v	レーザー スポット径 a	X線 スポット径 b	ショット数 (DVD一枚あたり)	測定時間 (DVD一枚あたり)
1 Hz	1 mm/s	300 μm	100 μm	30000	10時間
5 Hz	5 mm/s	300 μm	100 μm	30000	1時間30分
1 kHz	50 mm/s	30 μm	3 μm	1800000	30分

3. 観察結果

3.1 反射率変化と相変化の関係



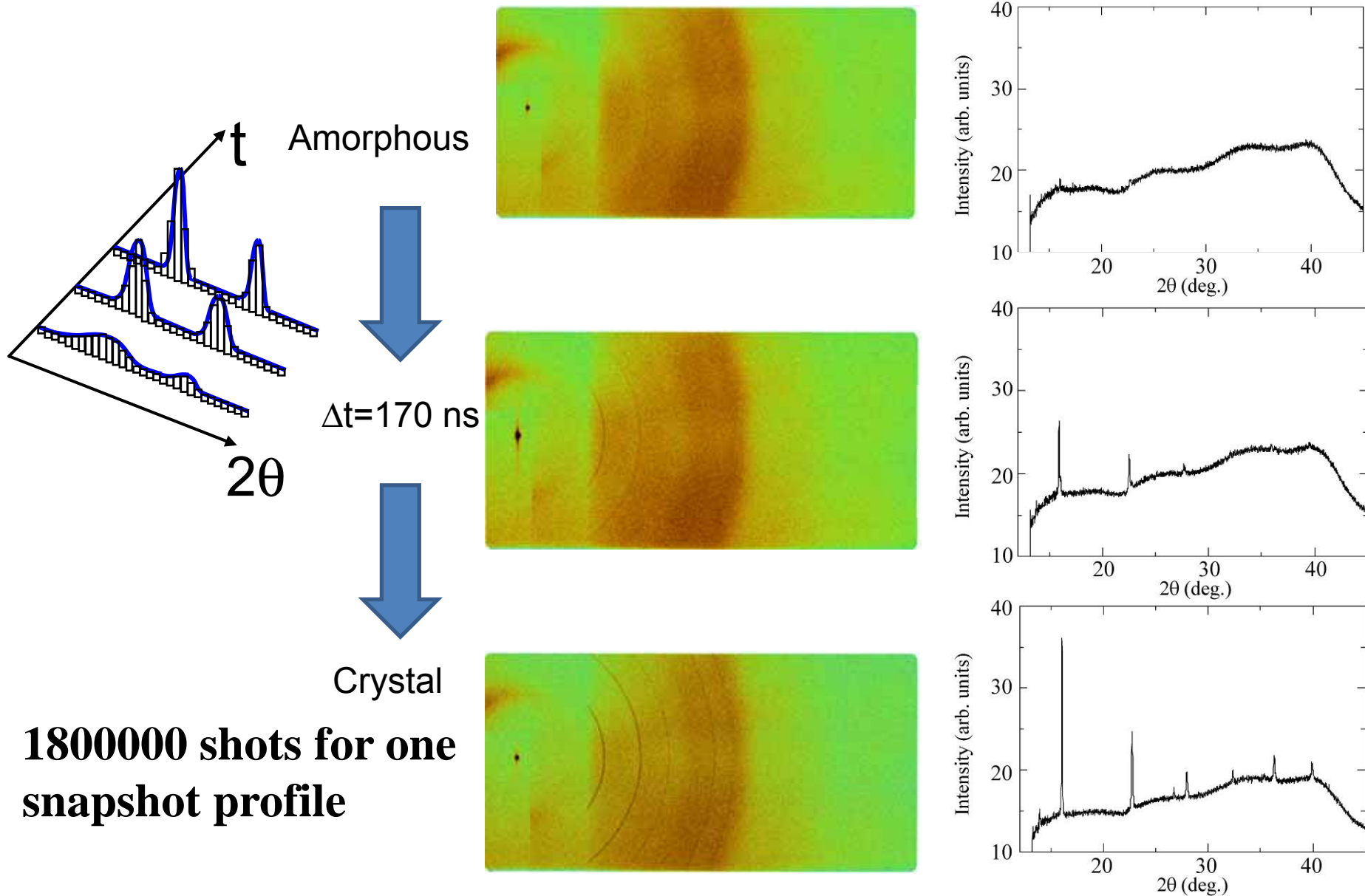
Time dependence of diffraction intensity and reflectivity



開始 : 90 ns
終了 : 273 ns

開始 : 85 ns
終了 : 206 ns

Snapshots of X-ray diffraction patterns for GST225



Snapshots of X-ray diffraction patterns for AIST

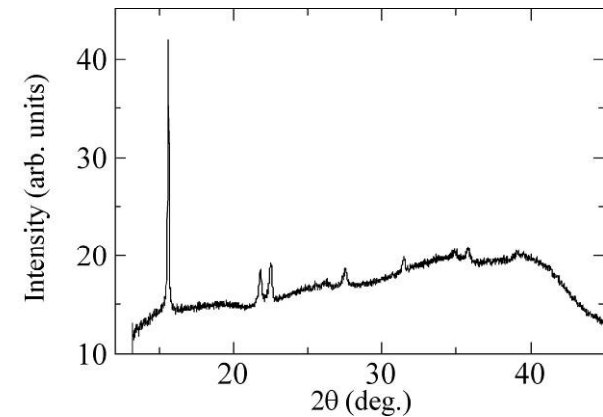
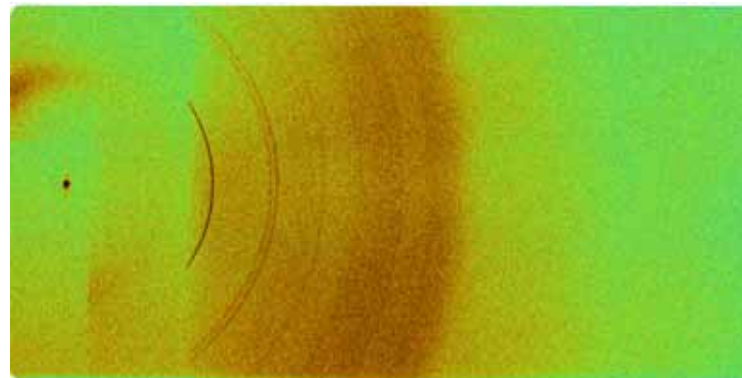
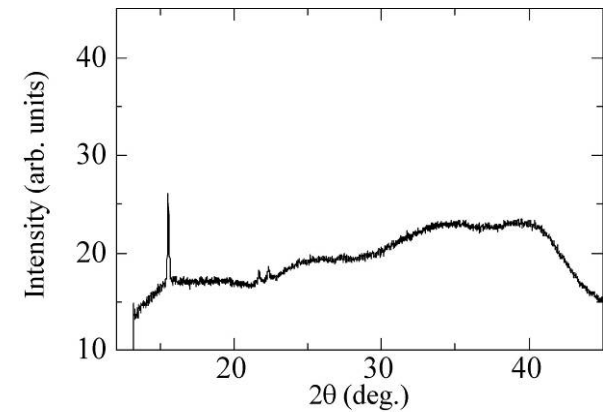
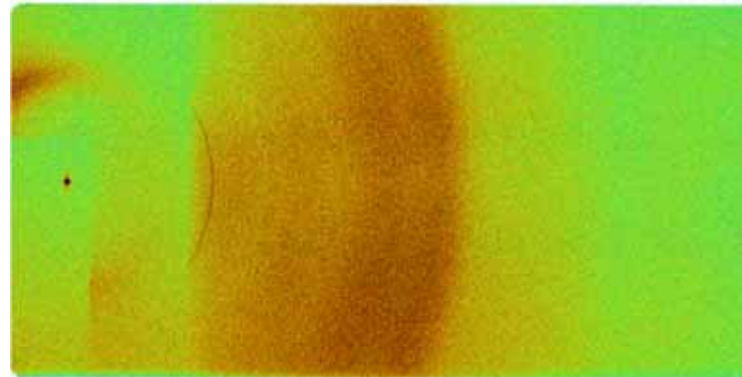
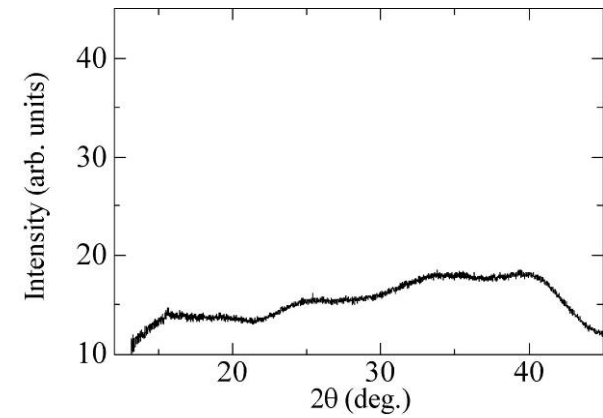
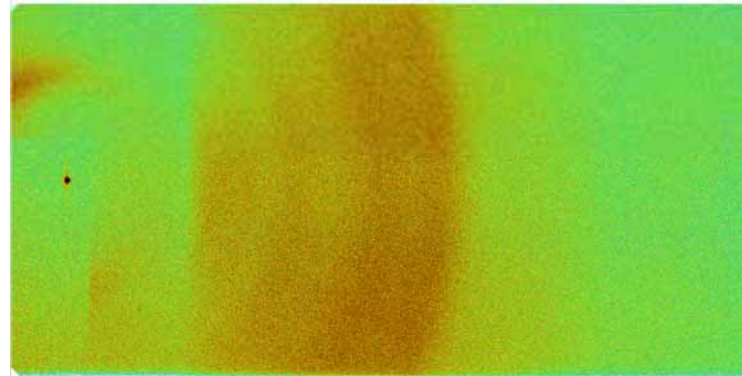
Amorphous



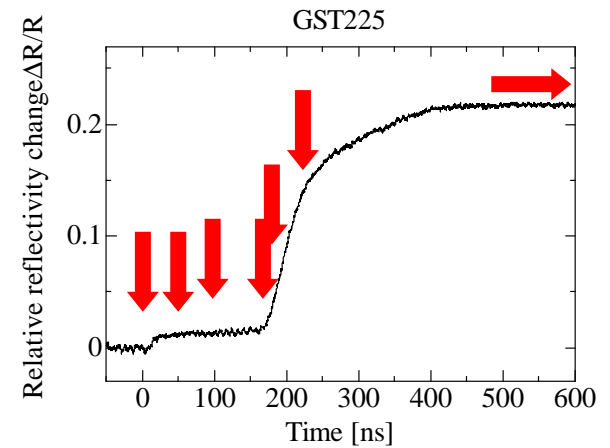
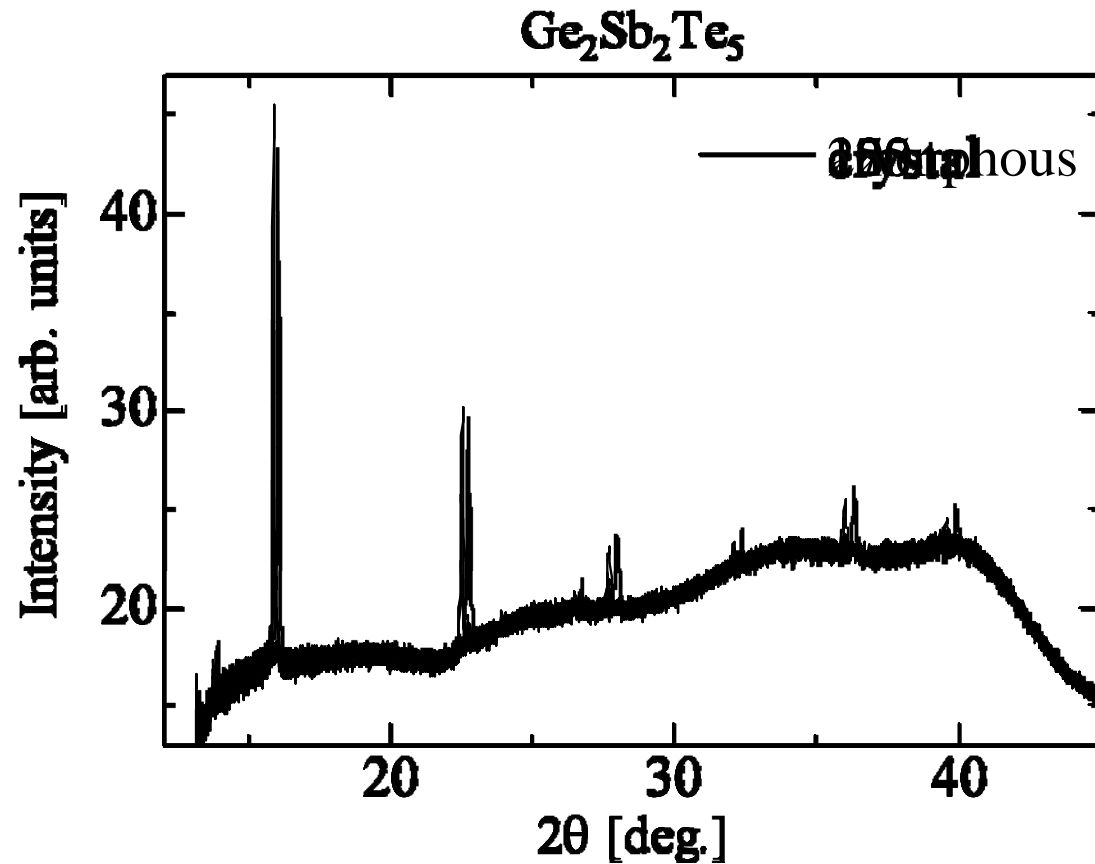
$\Delta t = 115$ ns



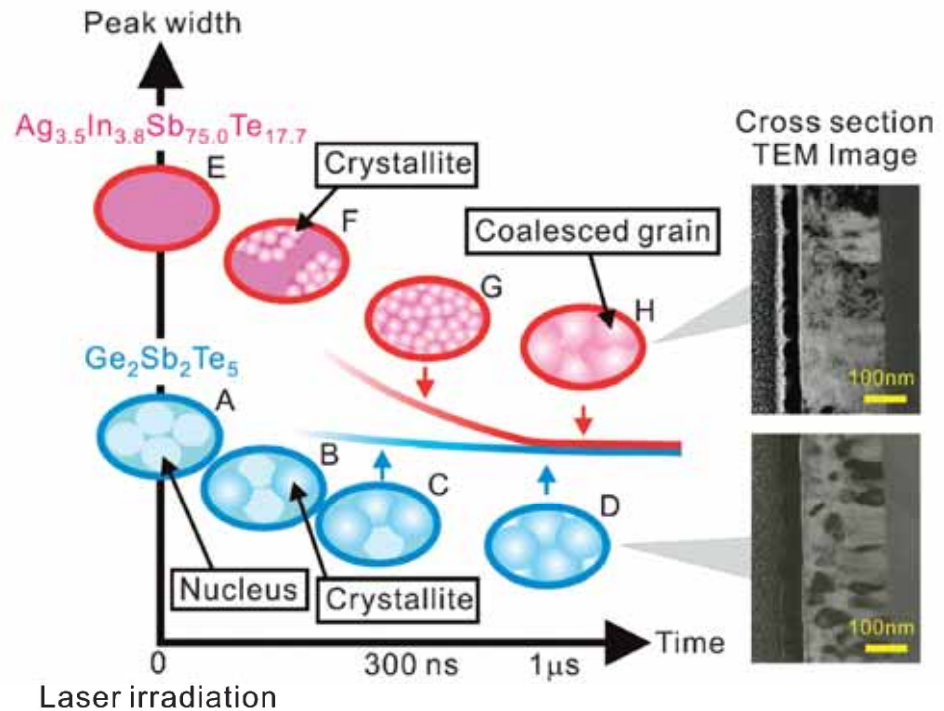
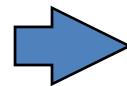
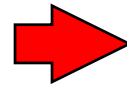
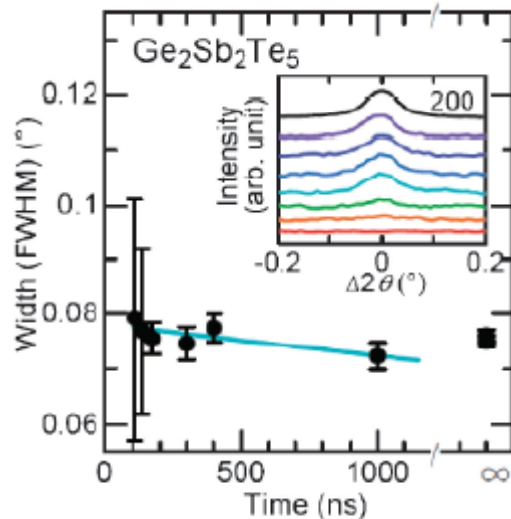
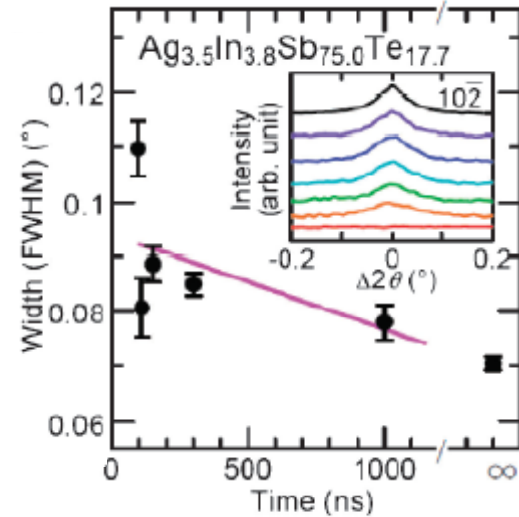
Crystal



Movie of X-ray diffraction pattern for GST225



Time-dependence of diffraction peak width (grain size and/or strain)



結晶成長過程の違い

Applied Physics Express, 1, 045001 (2008).

まとめ

- DVD光記録材料におけるアモルファス-結晶相変化について、時間分解X線回折法を適用した。
1. 反射率と構造変化の強い相関
 2. AISTとGSTで結晶化過程に相違
 - ▶ AISTは結晶化過程でブラッグピーク幅が大きく変化
 - GSTはピーク幅は不変、(過渡的な巨大格子定数(予備データより))

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田中義人(理研)

大島隆(理研)

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