Spatially resolved coarse grain measurements - problems and potentials

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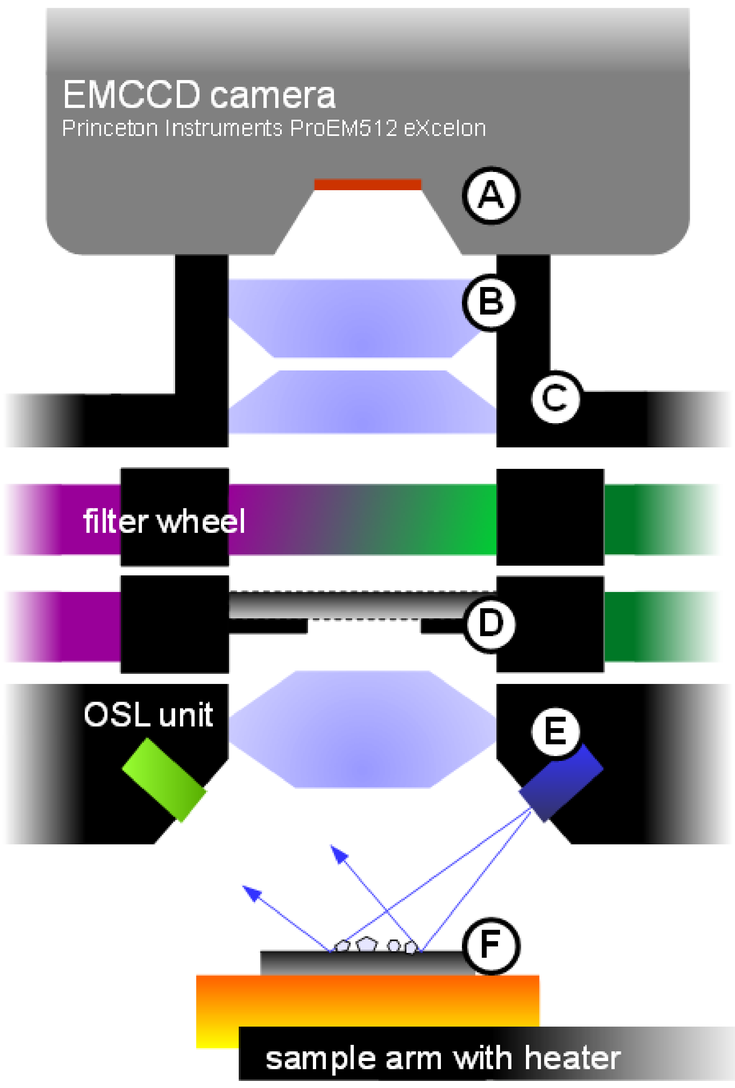
Introduction

Spatially resolved measurements with a highly sensitive EMCCD camera system offer new scientific applications in luminescence dating. An approach to obtain grain resolved dose information of coarse grain samples of quartz and feldspar is presented. New software and technical improvements allow the assessing of single-grain dose-distributions and provide a more flexible alternative to classic single-grain SAR measurements.



lexsyg research EMCCD camera system

A: thermoelectrically cooled back-illuminated UV-enhanced CCD with negligible dark noise and high quantum efficiency (~45% @380nm, ~70% @410nm). [1]

B: fused silica optics with high UV-transmission (>97% @380nm) and high numeric aperture (NA = 0.528)

C: a detector changer allows spatially resolved radiofluorescence measurements too

D: neutral density filter and an aperture for taking reflective light images ("photos")

E: if taking reflective light images the blue LEDs are used as photoflash light

F: polished steel sample discs produce less stray light because the angular incoming stimulation light is reflect towards opposite direction, thus less stimulation light reaches the detection

Analysis software

A dose evaluation software for coarse grain SAR measurements was developed. **AgesGalore2GUI** is a lexsyg adapted scripting program, using the image processing software ImageJ [2] and employs the spatially resolved dose evaluation software AgesGalore[3] as function libraries.

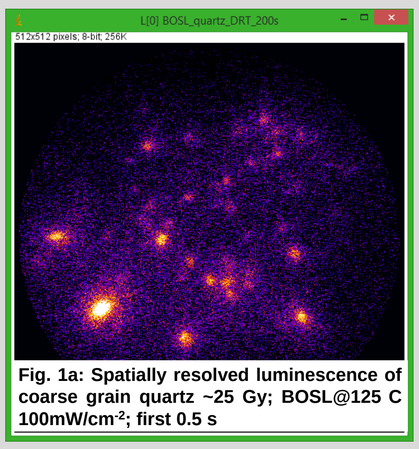


Fig. 1a: Spatially resolved luminescence of coarse grain quartz ~25 Gy; BOSL@125 C 100mW/cm^{-2}; first 0.5 s

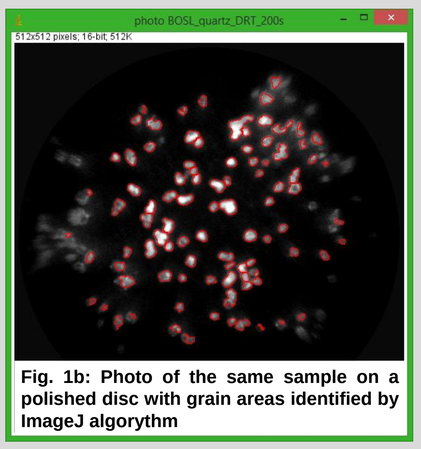


Fig. 1b: Photo of the same sample on a polished disc with grain areas identified by ImageJ algorythm

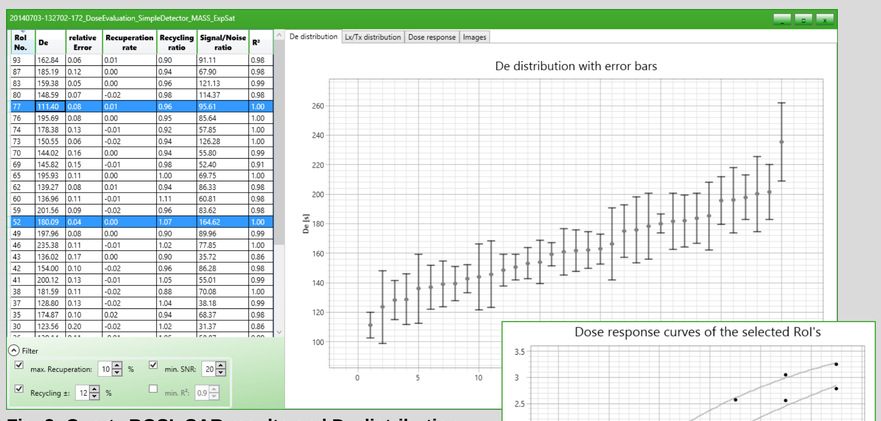


Fig. 2: Quartz BOSL SAR results and D_E distribution of a 200s DRT with rejection criteria activated.

Fig. 3: Dose response curves of two grains

Advantages

Compared to classic single-grain technique

- stimulation cross talk avoided because all grains are stimulated at once
- Every stimulation source can be applied: blue & green OSL, IRSL, TL, …
- Reduced effort in sample preparation

Challenges

Uncertainty in aliquot position Status: **solved**

Sample arm acceleration can cause sliding and rotation of sample discs during a measurement sequence in addition to a very small sample arm posiitoning uncertainty (<50 µm), which is negligible in standard approaches, but not for spatially resolved luminescence. An ImageJ image alignment algorithm, using reflective images as referencecorrects for movements, as long as these are small[4].

Grain definition by Regions of Interest (ROI) Status: **solved**

Manual seletion of grains is time consuming, but image recognition systems struggle in identifying low signal grains from luminescence images. A reproducible grain identification method with a high success rate is achieved through a sequence of image procressing functions based on the reflective light images[4].

Signal cross talk Status: **not solved yet**

Optical distortions, especially spheric aberration, can cause overlapping luminescence signals of neighbouring grains. Therefore D_e and luminescence properties of low signal grains may be masked by high signals from adjacent grains. While optical solutions lead either to a loss in detection sensitivity (achromatic optics & apertures) or significant smaller field-of-views (aspheric optics), the alternative of a mathematic image deconvolution (de-blurring) has to be evaluated[5].

Workflow data analysis

EMCCD image stack + **LexStudio2 sequence record**

I. image correction

- ✓ monitoring and correction of aliquot rotation and translation using reflective images
- ✓ X-ray and cosmic ray removal

II. grain area definition

- ✓ use reflective images for grain recognition
1. Remove large-area signal background
2. Convert into binary image by adaptive threshold algorithm
3. Identify particles by size and circularity

III. dose curve evaluation

- ✓ L_x/T_x calculation for each grain
- ✓ linear or exponential dose curve fitting
- ✓ error calculation by Monte Carlo or Gaussian error propagation (iinear fit only)

equivalent dose, error estimation and rejection criteria for each grain

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