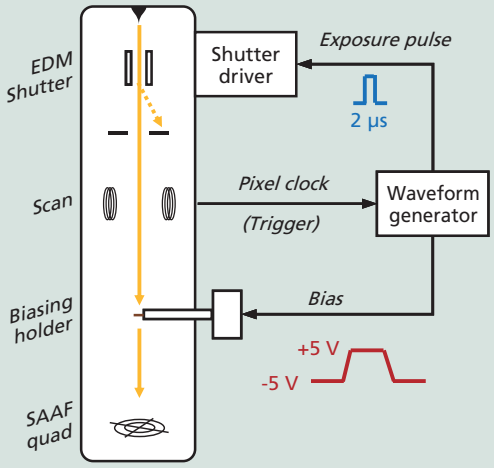
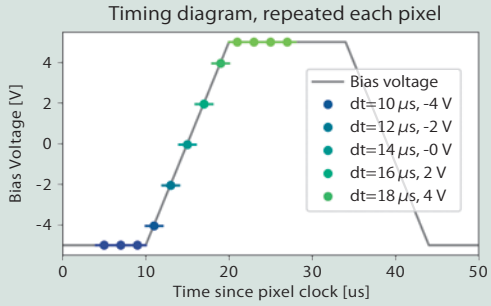
Application note

Time-resolved DPC imaging with EDM

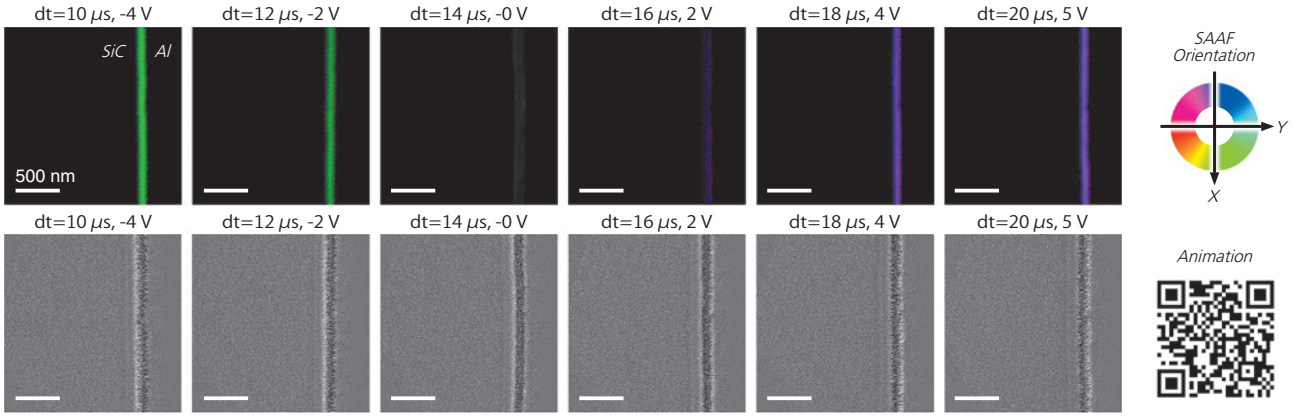
Experiment setup





The Electrostatic Dose Modulator (EDM) makes stroboscopic measurements simple for TEM and STEM. In this application note, pulsed illumination boosts the time resolution of Differential Phase Contrast (DPC) imaging using the already-fast SAAF Quad segmented detector[1]. The sample[2] is mounted on a chip in a biasing sample holder from Hummingbird Scientific. During each STEM pixel, a waveform generator ramps the bias voltage between -5 V and +5 V. After a variable delay time, a logic-level pulse to the input of the fast electrostatic shutter turns the probe beam on for 2 µs. Data collection can be automated.

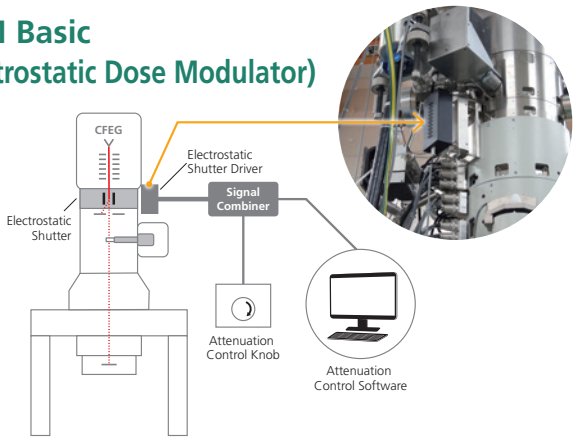
By varying the delay time of the exposure pulse, the sample is measured at different times during the bias waveform. A complete STEM image is recorded for each delay time (shown as dots in the timing diagram to the left). Even though each STEM image takes more than 10 seconds to record, the time resolution of the measurement is set by the 2 µs exposure pulse. The sample excitation can be accomplished using *in-situ* holders, IDES Luminary Micro, or other systems that produce repeatable dynamics in a sample.



Selected images from a tr-DPC measurement of a SiC MOS capacitor. The field in the sample is observed by the deflection of the beam at each probe position. The intensity in the top row of images shows the magnitude of this deflection, and color indicates the direction. The divergence of these indicates the charge density and is automatically calculated by the acquisition software (bottom row of images). The field is concentrated at the oxide interface between SiC (left) and Al (right). At t = 15 µs, the bias crosses zero volts and the field changes polarity.

1. Measurement conditions: Instrument JEM-F200, accelerating voltage 200 kV, STEM Lorenz mode, dwell time 50 microseconds, number of pixels 512 × 512. Experiment setup diagram is simplified. For detailed configuration information, consult your local JEOL sales office.
2. The sample is a MOS capacitor fabricated from Al, SiO_2, and n-type SiC, 200 nm thick, provided by Fuji Electric Co. Ltd.

EDM Basic (Electrostatic Dose Modulator)



The Electrostatic Dose Modulator (EDM) is a fast beam blanking system with a pre-sample electrostatic deflector, including electronics and software control. With EDM, the 100,000x improvement in blanking speed immediately improves the clarity of data taken at fast exposure times. EDM can also attenuate electron illumination without affecting imaging conditions, giving TEM and STEM users exceptional control over the dose on their samples.

Programmable STEM with EDM Synchrony

The optional Synchrony upgrade takes EDM's timing and synchronization capabilities to the next level. Synchrony can coordinate with a STEM controller, tracking the probe beam location as it scans across the sample. EDM's lightning-fast electrostatic blanking turns the beam on for a specified time at each pixel, or keeps the beam blanked to completely exclude sensitive regions from dose.

Pulse System

PULSE turboTEM

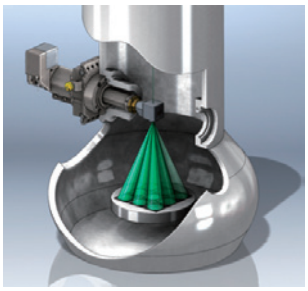
JEOL is pleased to offer Pulse for STEM. Pulse is a real time signal processor that enables digital imaging using standard analog STEM detectors. The device simply plugs in between your STEM detector and data acquisition system to deliver improved signal to noise ratios in your STEM images, particularly in low-dose or high-speed imaging modes.

TEMPO

TEMPO turboTEM

This is a completely new approach to STEM which inverts the typical approach to image formation by using the time required to reach a fixed number of electrons as the basis for pixel intensity rather than the number of electrons detected in a fixed amount of pixel dwell time. Once the desired number of electrons have been counted in a given pixel, the electron beam can then be rapidly blanked resulting in a significant reduction in overall dose applied to a specimen.

Relativity™ Electrostatic Subframing System



The IDES Relativity™ Electrostatic Subframing System multiplies the frame rate of cameras on JEOL TEMs. Microscopes equipped with Relativity™ achieve exceptional time resolution, data throughput, and advanced automation capabilities.

Luminary™ Micro Compact Specimen Photoexcitation System

Luminary™ Micro is a Compact Specimen Photoexcitation System (CPXS) for JEOL TEMs. With Luminary™ Micro, users can study laser-induced phenomena in situ using fast cameras. Combined with IDES/JEOL EDM fast shutter and/or Relativity™ subframing systems, Luminary™ Micro allows users to perform time-resolved studies using pump-probe methods on the microsecond time scale.

EM-IDES-006

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* Appearance and specifications are subjected to change without notice.

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