Fabrication of Nanopores in glass using femtosecond pulsed lasers

Kevin Ke, Alan J. Hunt
Department of Biomedical Engineering, University of Michigan, Ann Arbor, MI
Jeff Uram, Michael Mayor

1. PURPOSE

Ion channel proteins affect vital physiological functions such as nerve transduction and are important drug targets. Planar lipid bilayers (PLBs) allow recording of ion flows through ion channels under well-defined conditions. Reducing the diameter of the pore which supports the lipid bilayer improves the mechanical stability and the current noise of PLB's.

We present a method for fabricating nanopores in glass cover slides with diameters from 50 to 500 nm using ultrafast femtosecond lasers. PLBs on such devices might lead to portable sensors for detecting neurotoxins.

2. METHODS

Femtosecond and tightly focused ultrafast laser pulses produce a region of nonlinear optical breakdown in transparent dielectric materials causing ablation of the material by ionization.

Joglekar et al. 2003 found the process to be predominately Zener Tunneling followed by Avalanche ionization.

Approaching critical optical breakdown intensity (COBI), the ablation region can be as small as a few nanometers, significantly smaller than the diffraction limited spot size.

Circular scanning patterns using laser intensities close to COBI can be used to enlarge the ablation area without increasing the collateral damage associated with high intensity of lasers.

3. RESULTS

• Controlled Aperture Diameters
  - Configurable aperture diameter, 50 to 200 nm demonstrated
  - Smooth surface topology from reduced collateral damage at COBI

• Controlled Aperture Geometry
  - Minimal access resistance of aperture
  - Reduced capacitance minimizing capacitive current noise

• Optical Properties
  - Transparent glass coverslip (thickness ~160μm)
  - Suitable for fluorescence-based single molecule detection

• Other Characteristics
  - Mechanical and chemical robustness
  - Planar configuration suitable for parallel measurement and integration of microfluidics
  - Flexibility and control of aperture placement

This work was funded by NSF. K. Ke is partially funded by CBTP. Laser is provided by IntraLase Inc.