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Real-time Monitoring of Photothermal Porated Mammalian Cells by Electric Impedance Sensors

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Photothermal Nanoblade for Large Cargo Delivery into Mammalian Cells

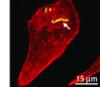
Endocytosis

Chemical methods

Photothermal Nanoblade
Delivering large cargo such as chromosomes, organelles, and intracellular pathogens via a large transient pore with pressure-driven injection.

Physical methods
Electroporation, Sonoporation, Optoporation, Microinjection

Deliverable Cargo Sizes

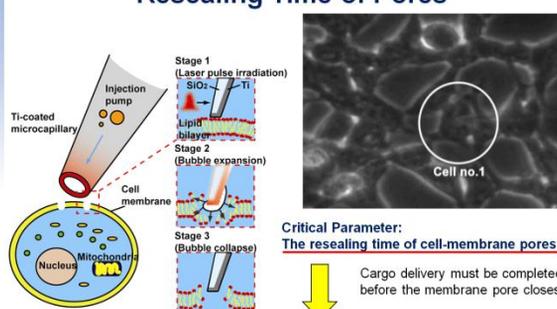
1nm	100nm	200nm	2µm
<ul style="list-style-type: none"> Molecule probes Quantum dots Proteins Microbeads ($\phi < 100\text{nm}$) 	DiRed lentiviral DNA adsorbed on 100 nm sphere into HEK293T	200 nm fluorescent polystyrene spheres into HEK293T	Bacteria into HeLa
			

Wu, T.-H. et al., *Opt. Express* 18(22), 2010
Wu, T.-H. et al., *Anal. Chem.* 83, 2011
French, C.T. et al., *Proc. Natl. Acad. Sci.* 108(23), 2011
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Resealing Time of Pores



Critical Parameter:
The resealing time of cell-membrane pores

↓
Cargo delivery must be completed before the membrane pore closes

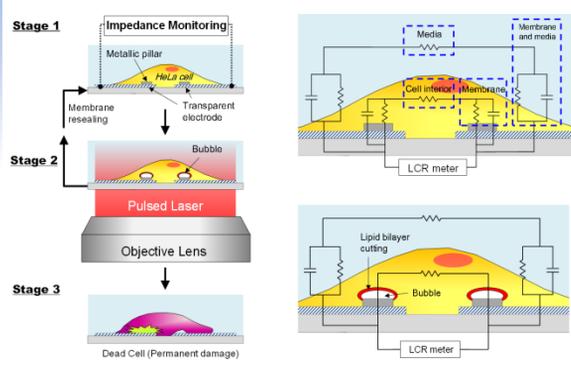
No measurement data has shown the resealing time of the membrane pore opened by photothermal technique.

Wu, T.-H. et al., *Opt. Express* 18(22), 2010
Wu, T.-H. et al., *Anal. Chem.* 83, 2011

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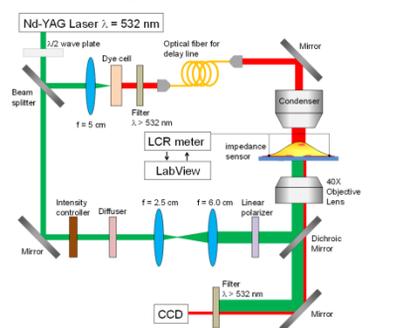
Electric Impedance Monitoring



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Laser Pulsing for Cavitation Bubbles

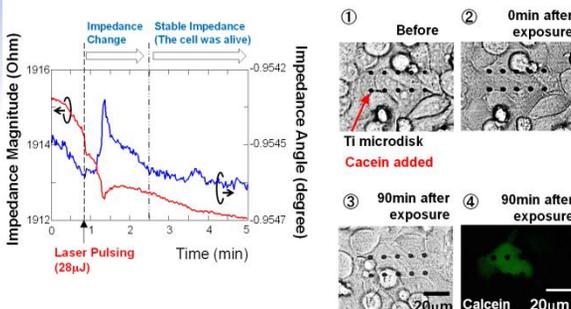


- Laser pulsing for triggering cavitation bubbles
- Time-resolved imaging for monitoring the generation of bubbles
- Real-time electrical impedance measuring by an LCR meter and LabView

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Impedance Measurement of a Viable Cell after Photothermal Poration



① Before ② 0min after exposure
Ti microdisk Calcein added

③ 90min after exposure ④ 90min after exposure
Calcein

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