

Improving Surgical Vision during Minimally Invasive Procedures

Stephan Beer, Intuitive Surgical Sàrl

SWISS PHOTONICS Workshop
Image Analysis Technologies for Robotics and Automation

September 12, 2023

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Intuitive Surgical

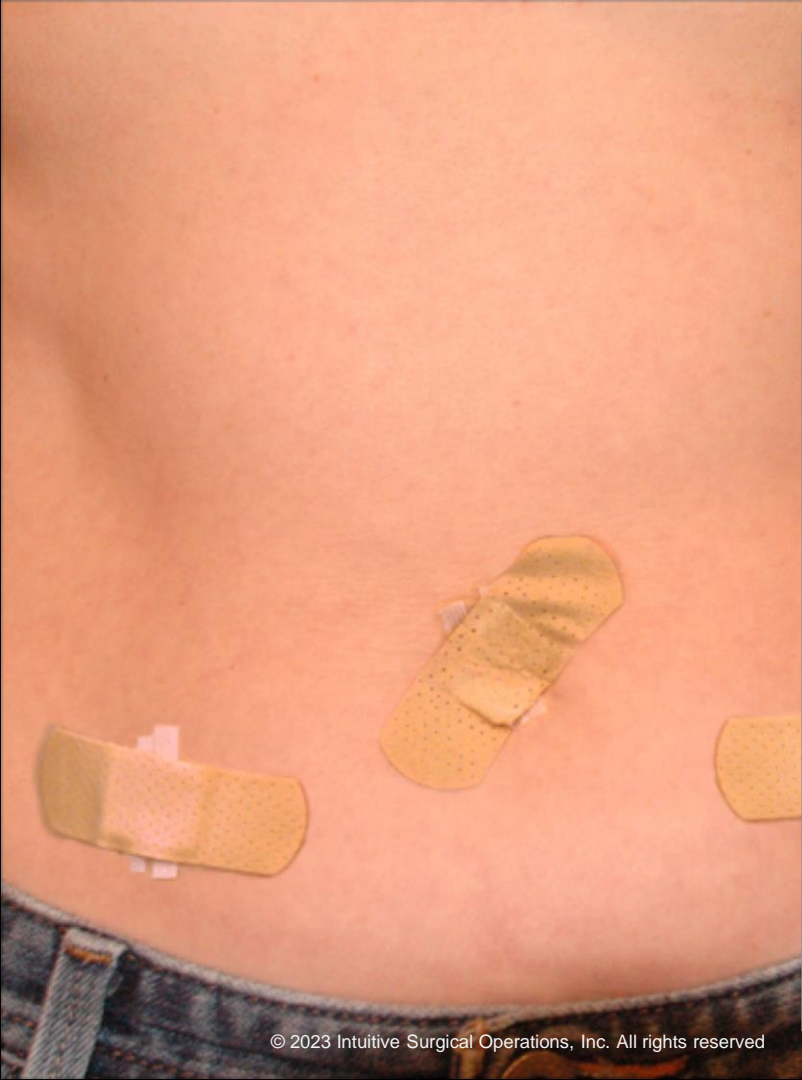
- Founded in 1995, IPO 2000
- Headquartered in Sunnyvale, CA
- 2022 Revenue - \$6.2B
- 8000 da Vinci surgical systems installed base in mid-2023
- Approximately 1.8M da Vinci procedures performed in 2022
- Numerous FDA and International Regulatory Clearances
- Primary Markets: Urology, Gynecology, General Surgery, Thoracic



da Vinci Xi



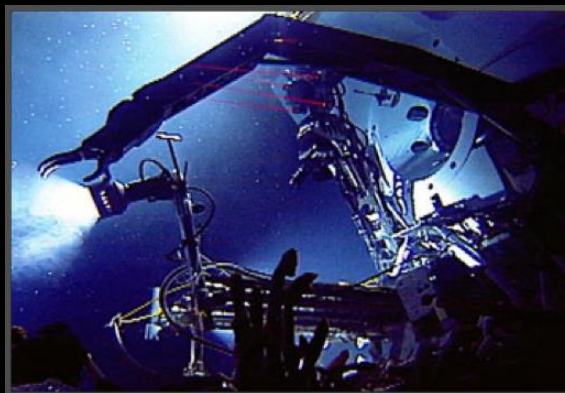






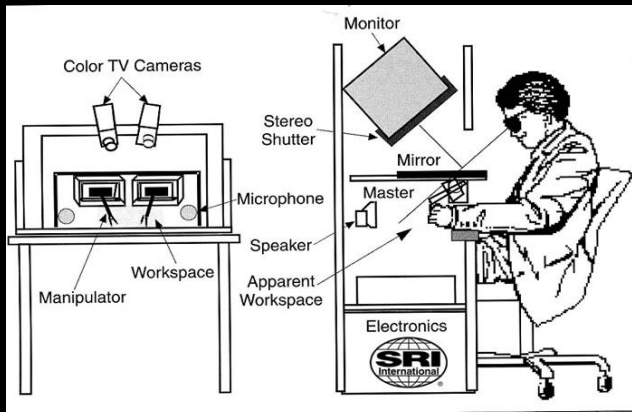
CENTRAL RESEARCH LABORATORIES

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Da Vinci Xi Surgical System



Patient cart



Vision cart



Surgeon console

Da Vinci Xi and da Vinci SP Surgical Systems



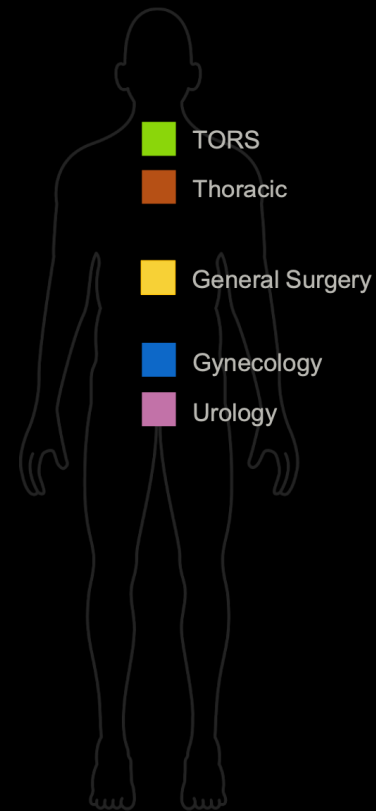
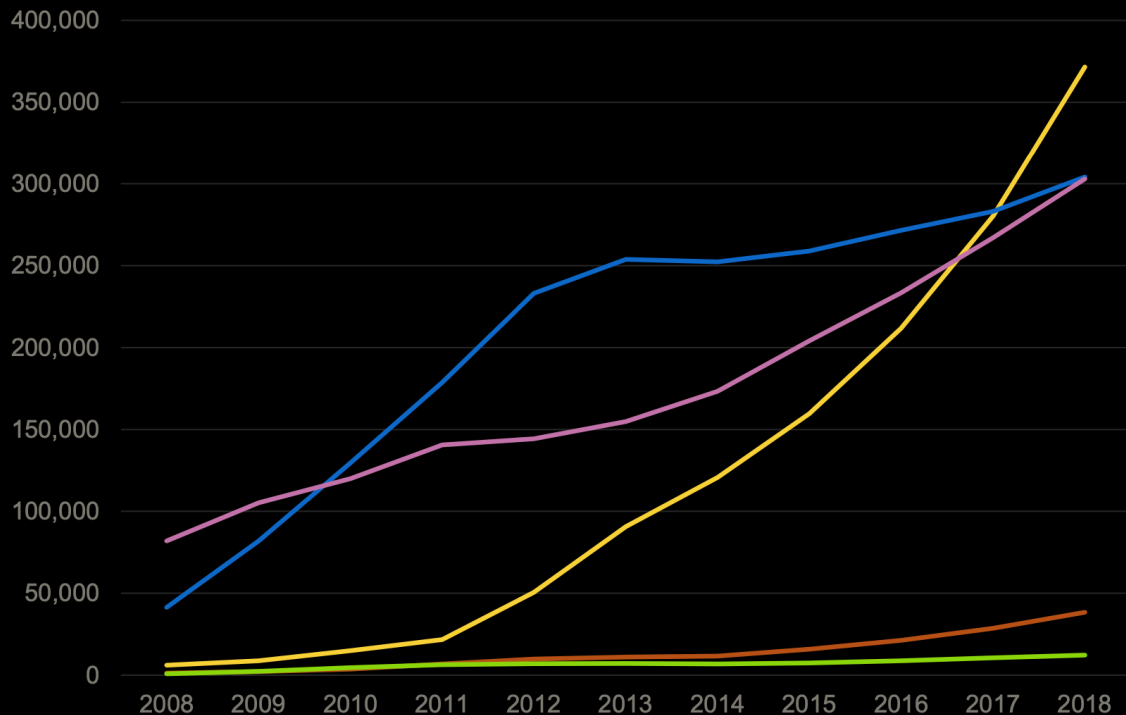
Patient cart



The da Vinci SP surgical system is not CE marked and cannot be placed on the market nor put into service.

Growth of da Vinci Procedures

As of December 31, 2018



Source: Intuitive data

1,800,000+

Procedures performed
on da Vinci® systems in 2022

3,000+

Peer-reviewed articles
published in 2022

1,200+

Da Vinci systems
placed in 2022

13,000,000+

Procedures performed on
da Vinci systems to date*

34,000+

Peer-reviewed articles
published to date

8,000+

Da Vinci systems in
hospitals globally*

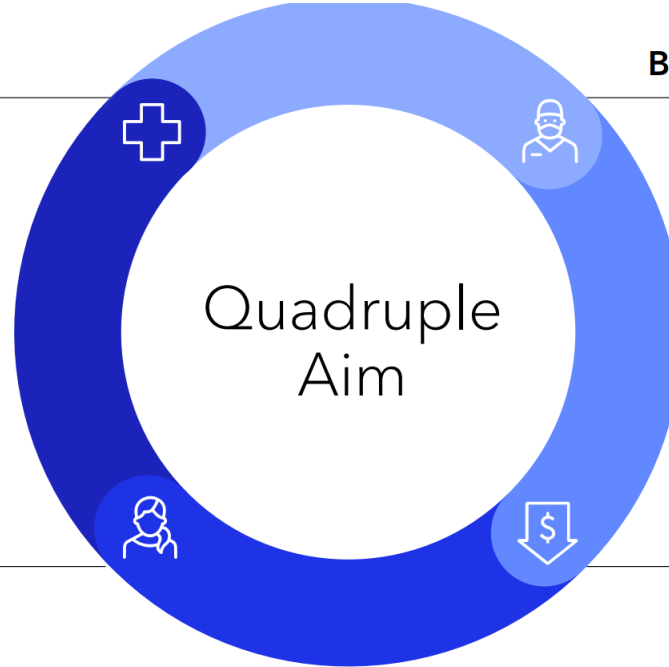
(*) As of Jun. 2023.

Better outcomes

- Length of stay
- Consistency of outcomes
- Surgical site infections
- Complications
- Return to OR
- Readmission

Better care team experience

- Ergonomics
- Dedicated teams
- OR efficiencies
- Analytics
- Training



Better patient experience

- Recovery
- Conversions
- Outpatient versus inpatient

Lower total cost of care

- Clinical cost
- Direct costs
- Clinical variation

As a community, we must progress beyond the current state

US National Complication Rates

Focus on improvement:

- Morbidity / complications
- Surgical margins
- Reoperation rate

Rectal

35.98%²

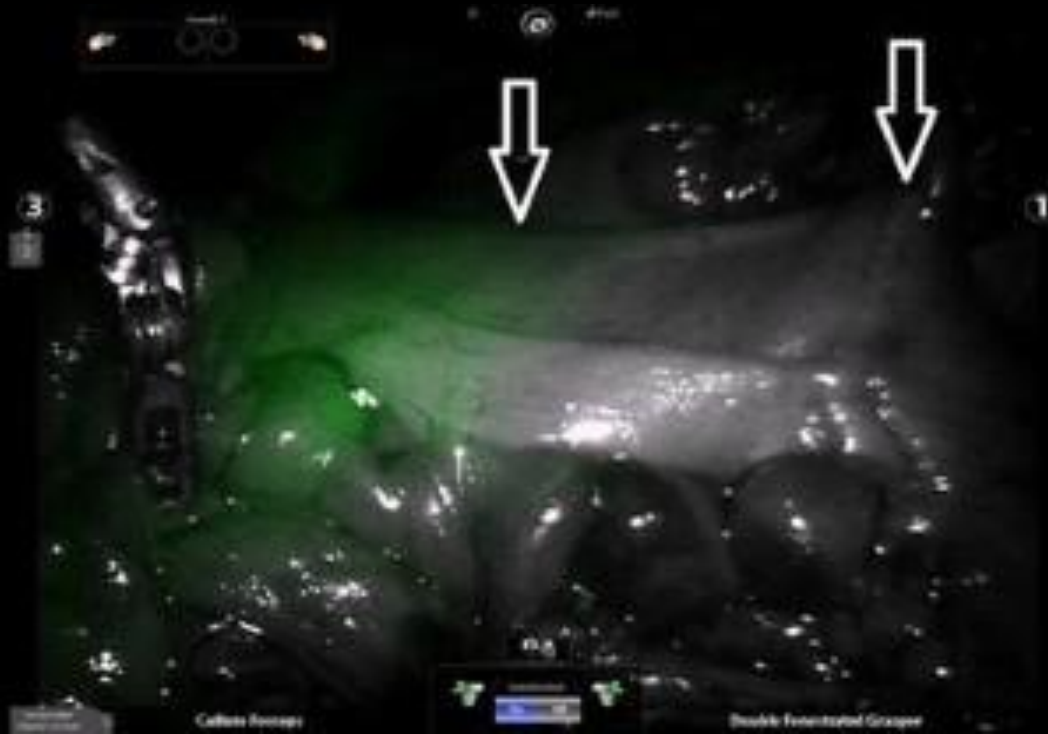
Complex Ventral

17.1%³

²Chen S-T, Wu M-C, Hsu T-C, Yen DW, Chang C-N, Hsu W-T, et al. Comparison of outcome and cost among open, laparoscopic, and robotic surgical treatments for rectal cancer: A propensity score matched analysis of nationwide inpatient sample data. J Surg Oncol. 2017:1-9.

³Martin Di Campo et al. - Comparative analysis of perioperative outcomes of robotic versus open transversus abdominis release. Surg Endosc. 2017 Jul 21. doi: 10.1007/s00464-017-5752-12.

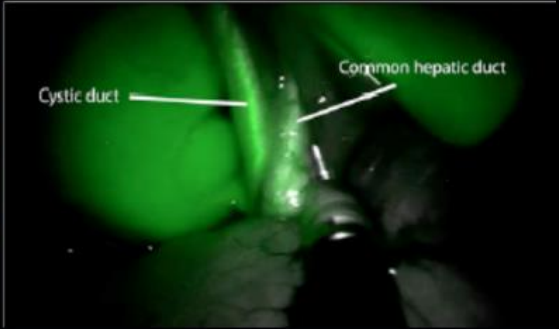
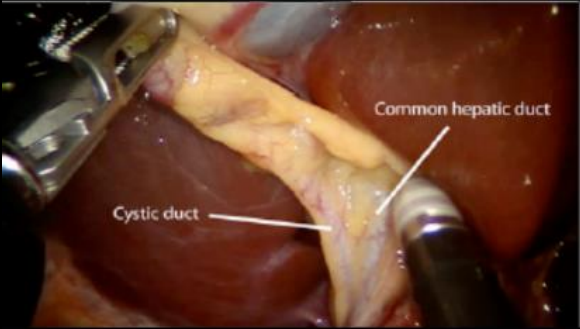
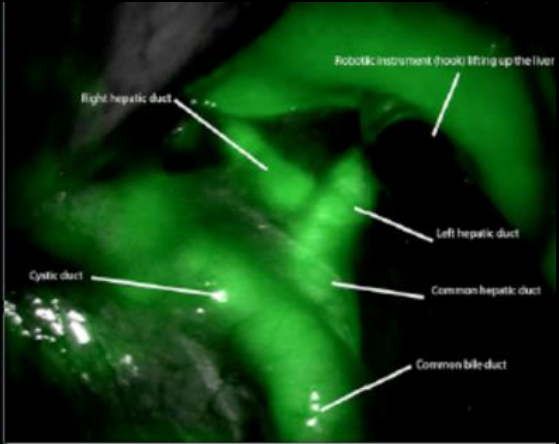
Fluorescence Imaging with ICG (Firefly)



Hellan et al., Surgical Endoscopy, 2014

Imaging agents, such as indocyanine green (ICG), should be administered per the manufacturer's instructions for use. Surgery should only be performed when the vision system provides sufficient visualization to safely perform surgical tasks.

Bile Duct Injury and Fluorescence Imaging with ICG



Imaging agents, such as indocyanine green (ICG), should be administered per the manufacturer's instructions for use. Surgery should only be performed when the vision system provides sufficient visualization to safely perform surgical tasks.

Spignolio et al, Surgical Endoscopy, 2013

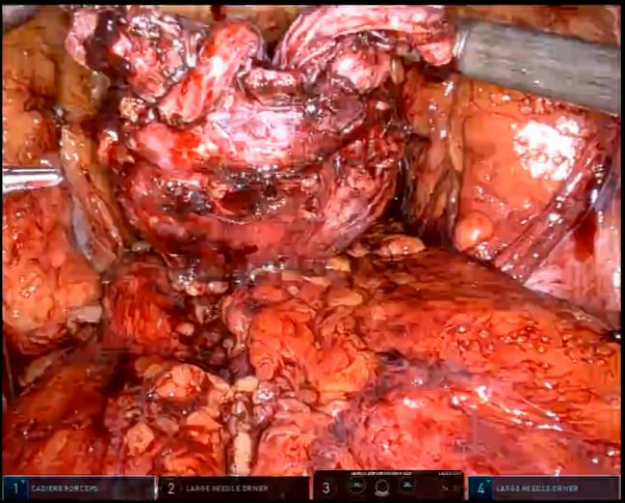
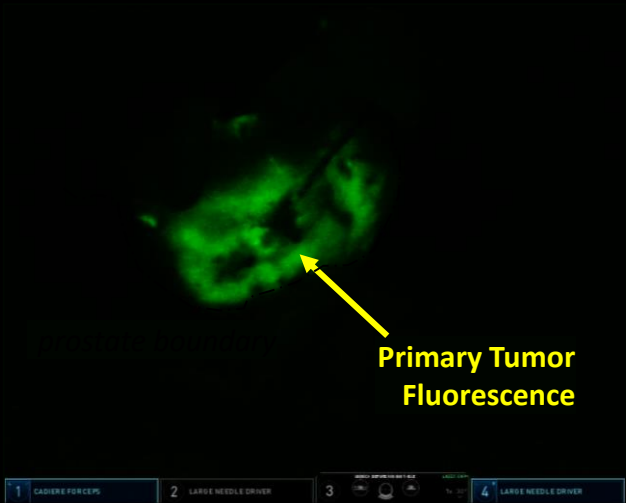
Focusing on better oncologic outcomes - IS002

PSMA binding agent – primary tumor identification

WHITE LIGHT IMAGING



NEAR-INFRARED FLUORESCENT IMAGING



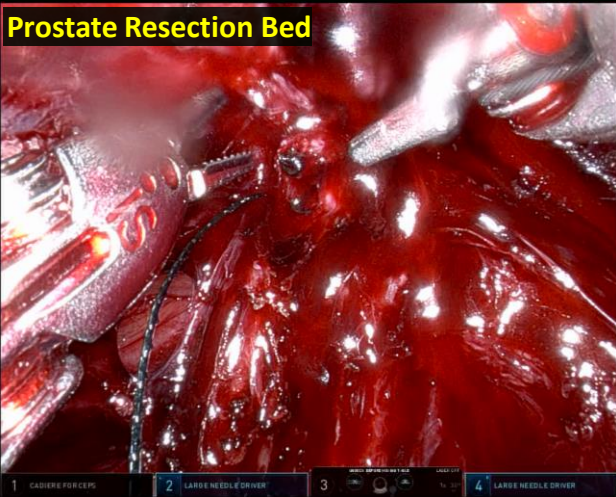
The technology presented is not CE Marked and cannot be placed on the market nor put into service.

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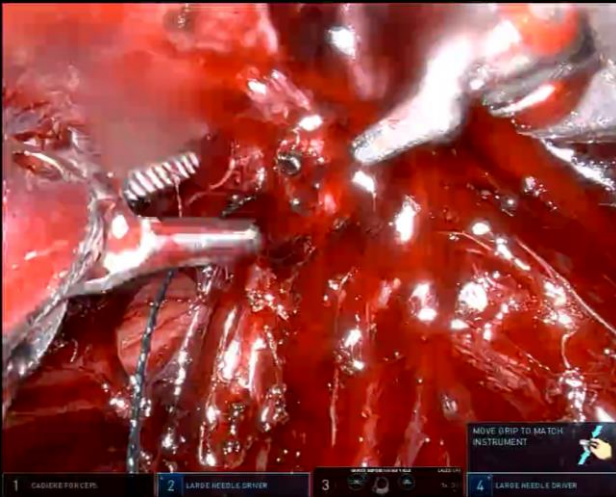
Focusing on better oncologic outcomes - IS002

PSMA binding agent – residual disease identification

WHITE LIGHT IMAGING



NEAR-INFRARED FLUORESCENT IMAGING

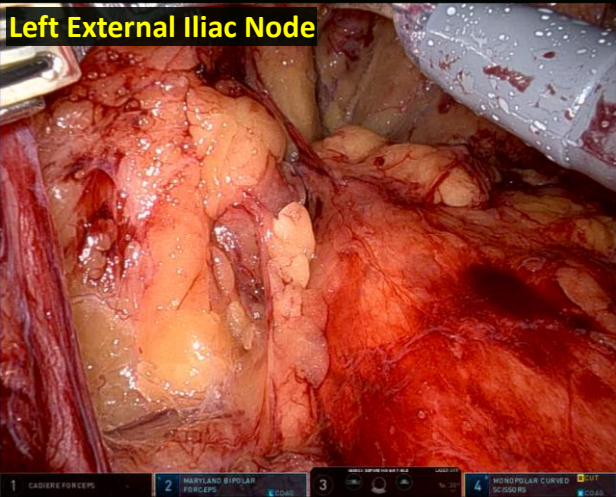


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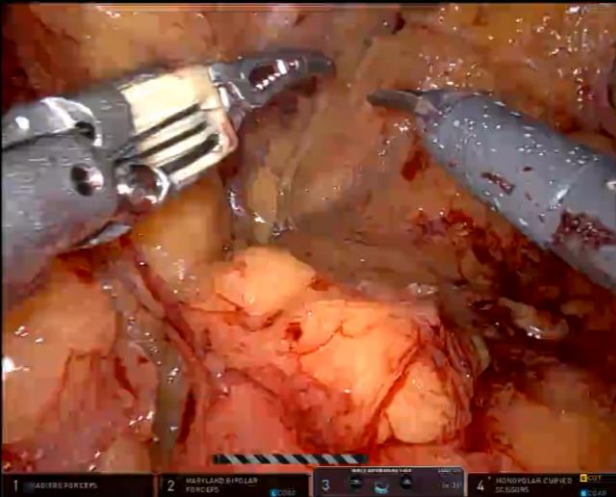
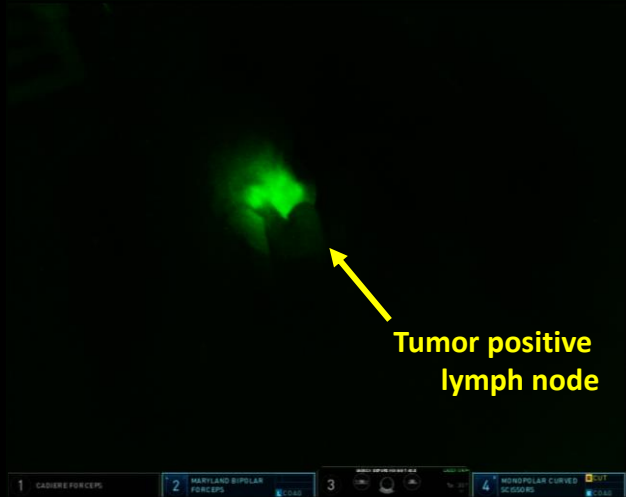
Focusing on better oncologic outcomes - IS002

PSMA binding agent – positive lymph node identification

WHITE LIGHT IMAGING



NEAR-INFRARED FLUORESCENT IMAGING



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Improving Imaging

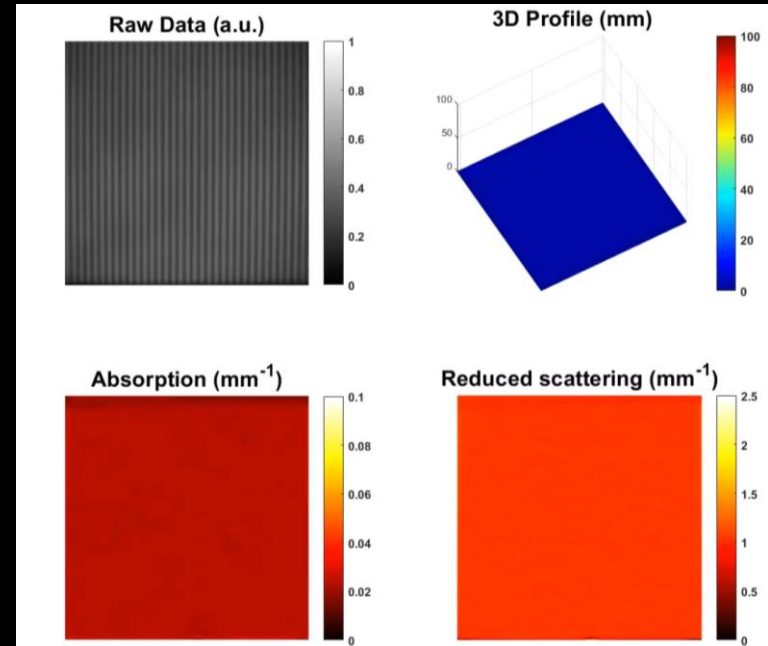
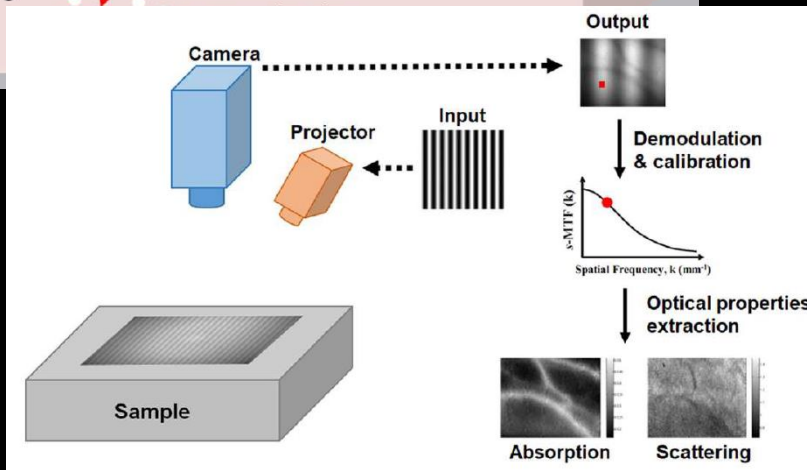
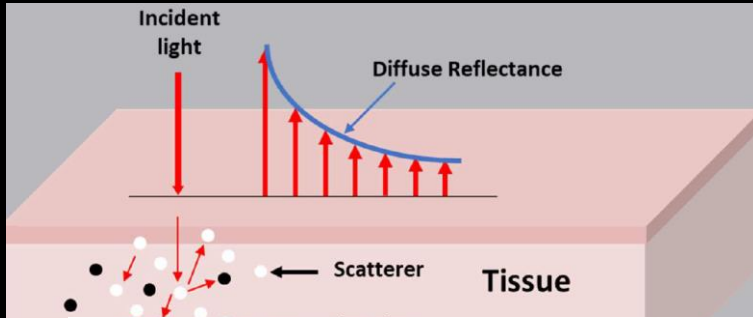


Sensors: Low-power, pixel size, sensor size, global shutter?

Optics: narrow (not flat), prisms, coatings

Illumination: wall-plug efficiency, beam profile, stable (aging), color adjustable

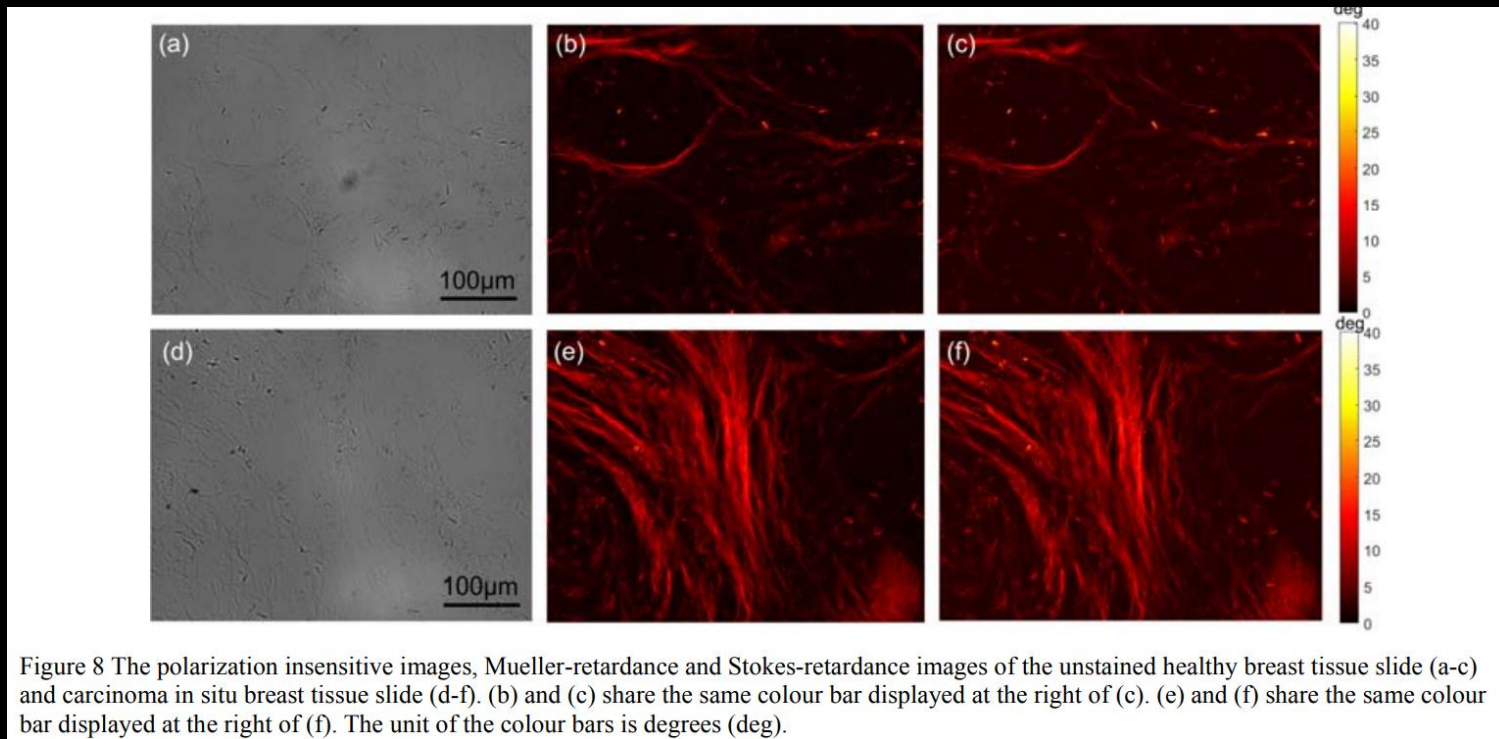
New Imaging Modalities: Spatial Frequency Domain Imaging SFDI



Illumination

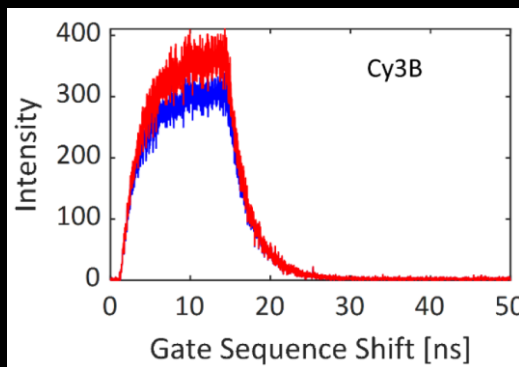
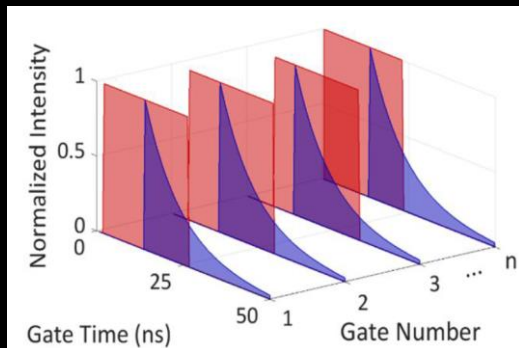
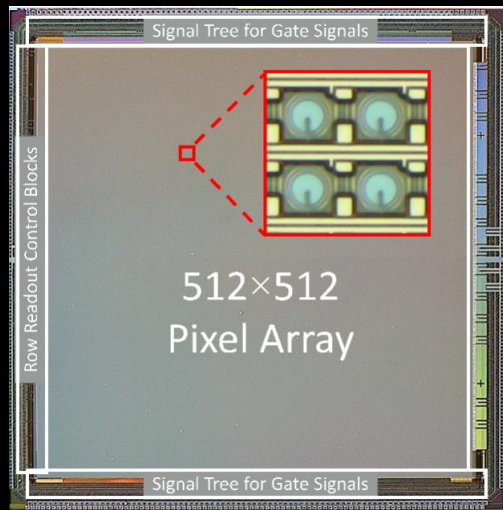
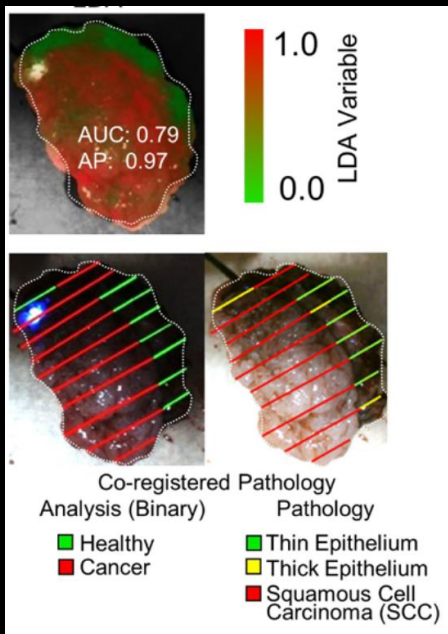
Aguénounon et al, Biomed Opt Exp, 11(10), 2020

New Imaging Modalities: Polarimetric Imaging



Qi et al. Assessment of tissue polarimetric properties using Stokes polarimetric imaging with circularly polarized illumination. *J. Biophotonics*. 2018; 11:e201700139. <https://doi.org/10.1002/jbio.201700139>

New Imaging Modalities: FLIM with SPADs



Weyers et al, Fluorescence lifetime imaging for intraoperative cancer delineation in transoral robotic surgery. *Transl Biophotonics*. 2019 Dec;1(1-2):e201900017. doi: 10.1002/tbio.201900017

Ulku et al., Wide-field time-gated SPAD imager for phasor-based FLIM applications, doi: 10.1088/2050-6120/ab6ed7

The future is bright

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Regulatory and Legal Disclaimers and Statements

Product Information

Da Vinci X & Xi Surgical Systems

The Intuitive Surgical Endoscopic Instrument Control Systems (da Vinci X and da Vinci Xi Surgical Systems) are intended to assist in the accurate control of Intuitive Surgical Endoscopic Instruments during urologic surgical procedures, general laparoscopic surgical procedures, gynecologic laparoscopic surgical procedures, general thoracoscopic surgical procedures, and trans-oral otolaryngology surgical procedures restricted to benign tumors and malignant tumors classified as T1 and T2, and for benign base of tongue resection procedures. The systems are indicated for adult and pediatric use (except for trans-oral otolaryngology surgical procedures). They are intended to be used by trained physicians in an operating room environment.

The da Vinci X and da Vinci Xi Surgical Systems are class IIb medical devices CE marked (CE 2460) under the European Medical Devices Directive (93/42/EEC), manufactured by Intuitive Surgical, Inc. Refer to Instructions For Use before use.

Firefly

The da Vinci Firefly Imaging System is intended to provide real-time endoscopic visible and near-infrared fluorescence imaging. The da Vinci Firefly Imaging System enables surgeons to perform minimally invasive surgery using standard endoscopic visible light as well as visual assessment of vessels, blood flow and related tissue perfusion, and at least one of the major extra-hepatic bile ducts (cystic duct, common bile duct or common hepatic duct), using near infrared imaging.

Imaging agents, such as indocyanine green (ICG), should be administered per the manufacturer's instructions for use. Surgery should only be performed when the vision system provides sufficient visualization to safely perform surgical tasks.

Da Vinci SP

Da Vinci SP Surgical System is not CE Marked and cannot be placed on the market nor put into service.

Endoscope

The endoscope is intended to provide real-time, 3D, high-definition imaging enabling surgeons to perform minimally invasive surgery. The endoscope supports two modes: standard visible light color

imaging mode and a near-infrared fluorescence imaging mode consisting of a black and white surgical image with the near-infrared fluorescence depicted in a color overlay.

The endoscope is a class IIa medical device CE marked (CE 2460) under the European Medical Devices Directive (93/42/EEC), manufactured by Intuitive Surgical, Inc. Refer to Instructions For Use before use.

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