Professor Nimmi Ramanujam, Ph.D.
Director, Global Women’s Health Technologies
Professor of Biomedical Engineering,
Global Health and Pharmacology, Duke University

- To improve women’s health through technological innovation
- To increase persistence of women in STEM
- To increase participation of women in innovation and entrepreneurship

Henrietta Lacks 1930-1951

Cervical Cancer Decline from 1975-2010
GLOBOCAN 2012 (IARC)
Reduction in Mortality attributed to early Screening and Diagnosis

Screening  Diagnosis  Treatment
Cervical Cancer Mortality
Source: IARC (2012)

VIA/HPV
Colposcopy
Cryo/LEEP
Cancer Treatment

Visual Inspection with Acetic Acid (VIA)
Challenge
Quality Control and Teleconnectivity

Mobile Screening in Tamil Nadu, India

Challenge
Health Worker Shortage

Majengo Clinic, Moshi Tanzania

Primary care Provider
Pap, HPV and Colposcopy
In One Visit

Specialist
Provide consultation on Images and guide biopsy

No cancers lost to follow up
No unnecessary referrals and biopsies
Low capital investment
Reimagining the Colposcope

Colposcopy/Cervicography

Leisegang Optik 2 @ 3.75, 7.5, and 15 X US$ 20,000 and >150 lbs

Canon SX50HS @ 2.75X US$ 500 and 1.5 lbs

Portable Colposcopes
Can we put the Light Source and Camera on a Tampon?

POCkeT (Point Of Care Tampon) Colposcope

Colposcopy/Cervicography

POCkeT Colposcope
US$ 500
7 - 27 μm resolution

Leisegang Optik 2
US$ 20,000
5 - 35 μm resolution
### Illumination Characteristics

<table>
<thead>
<tr>
<th>System</th>
<th>Illumination Type</th>
<th>Electrical Power (W)</th>
<th>Optical Power (mW)</th>
<th>Irradiance (mW/cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leisegang Optik</td>
<td>White LED 5000k</td>
<td>18</td>
<td>79.3</td>
<td>183.9</td>
</tr>
<tr>
<td></td>
<td>SP Red Filter</td>
<td>18</td>
<td>32.1</td>
<td>77.3</td>
</tr>
<tr>
<td>POCeT Colposcope</td>
<td>White LED 5000k</td>
<td>2.4</td>
<td>1.07</td>
<td>2.36</td>
</tr>
<tr>
<td></td>
<td>Green LEDs</td>
<td>1.2</td>
<td>0.36</td>
<td>0.95</td>
</tr>
</tbody>
</table>

### Detector Characteristics

<table>
<thead>
<tr>
<th>System</th>
<th>Detector Type</th>
<th>Resolution (MP)</th>
<th>Diagonal FOV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leisegang Optik</td>
<td>18 MP CMOS</td>
<td>35 μm</td>
<td>30 mm</td>
</tr>
<tr>
<td>POCkeT Colposcope</td>
<td>5 MP CMOS</td>
<td>35 μm</td>
<td>52 mm</td>
</tr>
</tbody>
</table>

Resolution – 35 μm or 14 lp/mm
Concordance between the Leisegang Optik and the POckeT Colposcope

Clinical Study Protocol (DUMC)
Speculum Placement + Vinegar (5% Acetic Acid)

Leisegang Optik 2
POckeT Colposcope
35 Image Pairs
Standard of Care Biopsy
Blinded Image Interpretation – Ob./Gyn. (3 Duke & 3 International)

Reid Index
Lesion Margin, Color, Vessels
Improving Specificity

Imaging Blood Vessels with a Green Filter

Leisegang Optik

POCkeT Colposcope

Can we use Neovascularization to Detect CIN 2+?

Chang et al., JBO, 2009
High Resolution Vascular Imaging

LED source
Optical fiber
Filter wheel
(440, 540, 580, 600 nm)

Iris (d2)
Beam splitter
Objective 4X
Sample

Resolution = 3.1 µm

Dysplasia (14)  SCC (8)

Count

High-Resolution Vascular Imaging

Ratio (nm/nm)  Normal  Dysplasia  SCC

440/600

540/600

580/600

High-Resolution Vascular Imaging

Normal  Dysplasia  SCC

Gold standard  Gabor mask

Ratio

540/600

500 µm
Diagnostic Vessel Characteristics

Large vessels

Small vessels

Classification results

Features used: tortuosity, diameter, area fraction

Summary

• Rethinking the implementation of the traditional colposcope to a tampon configuration enables low cost innovation with comparable performance

• Vascular contrast decoupled from scattering is enhanced in severe dysplasia

• Multi wavelength dark field microscopy unravels vessel contrast at different depths in precancerous lesions
Funding

• NIH R21 Quick Trials – 2012-2015
• NIH RO1 2015-2020
• NIH R01 Quick Trials 2015-2018
• NIH STTR Phase II grant 2014-2016
• Duke School of Medicine Grant 2014-2015
• DGHI – PRATT seed grant 2014-2015