DOCUMENT			
DELIVERABLE NUMBER	**D8.10**	DUE DATE	**31.08.2011**
TYPE OF DELIVERABLE	**REPORT**	ACTUAL DATE	**14.09.2011**
ISSUED BY	**VUB**	PAGES	**9**
CONTRIBUTING WP / TASK	**WP8/ TASKS 8.2, 8.3, 8.4 & 8.5**	ANNEXES	**0**
CONFIDENTIALITY STATUS	**RESTRICTED TO GROUP (RE)**		

PROJECT	
GRANT AGREEMENT NO.	**223989**
ACRONYM	**ICU**
TITLE	**INFRARED IMAGING COMPONENTS FOR USE IN AUTOMOTIVE SAFETY APPLICATIONS**
PROJECT START	**01.05.2008**
CALL	**FP7-ICT-2007.3.5**
FUNDING SCHEME	**STREP**
PROJECT WEBSITE	**WWW.ICU-EU.COM**

ICU PROJECT DELIVERABLE

DELIVERABLE D8.10

FINAL REPORT ON DISSEMINATION CONTAINING RESULTS ON PUBLICATIONS, ATTENDED CONFERENCES, EVENTS, FAIRS, AND EDUCATION

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REVISION HISTORY				
VER.	DATE	PAGES	NOTES	AUTHOR
1.0	14.09.2011	9	Final Document	Heidi Ottevaere/Hugo Thienpont

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1. Executive summary

This deliverable is part of Tasks 8.2, 8.3, 8.4 & 8.5 as specified in Annex I to the Grant Agreement. ICU has conducted considerable dissemination efforts during the full project. The consortium tried to raise awareness about the ICU initiative, not only through participation at conferences, workshops and meetings, but also through the distribution of press releases. As described in the DoW, ICU published several journal publications, participated to the major photonics related conferences and especially those including an extended industrial program. In this report an overview of the dissemination activities of the whole ICU project period is given.

2. Final report on dissemination containing results on publications, attended conferences, events, fairs, and education

2.1. Dissemination through publications

Scientific results of ICU were/will be published in three peer-reviewed journals:

1) F. Niklaus et al., “Wafer bonding with nano-imprint resists as sacrificial adhesive for fabrication of silicon-on-integrated-circuit (SOIC) wafers in 3D integration of MEMS and ICs”, Sensors and Actuators A: Physical, Volume 154, Issue 1, pages 180-186, 2009.

2) Martin Lapisa, Göran Stemme, Frank Niklaus, ”Wafer-Level Heterogeneous Integration for MOEMS, MEMS, and NEMS”, IEEE Journal of Selected Topics in Quantum Electronics, Vol.17, No.3, pp.629-644, 2011. (invited paper)

3) Fredrik Forsberg, Niclas Roxhed, Andreas Fischer, Nils Høivik, Adriana Lapadatu, Martin Bring, Gjermund Kittilsland, Per Eriksson, Björn Samel, Göran Stemme, Frank Niklaus, “Very Large Scale Heterogeneous Integration (VLSHI) and Wafer-Level Vacuum Packaging for Next Generation Low-Cost Infrared Imager for Industrial, Automotive, and Security Applications”, IEEE Transactions on Industrial Electronics, submitted, 2011.

Part of ICU has been disseminated in a chapter of a book:

1) F. Niklaus, J.-Q. Lu, “Polymer Adhesive Wafer Bonding” in Handbook of Wafer Bonding, edited by P. Ramm, J.-Q. Lu, WILEY-VCH Verlag, to appear in fall 2011.

2.2. Dissemination through attended conferences, events and fairs

ICU participated to and disseminated at events including meetings, workshops and conferences. A highlight of the dissemination activities was the visibility and presence of ICU at the SPIE Photonics Europe Conference, held in April 2010 in Brussels (Belgium). This event is known as the one of the most prestigious conference in the field of photonics in Europe. ICU contributed in the Industrial session on IR Detection at the Optical Sensing and Detection Conference with 3 invited presentations given by the partners. With the booth at the European Network Village ICU

was introduced to the general public through some news flashes on Flemish TV (VTM News) and TV Brussels.

11 Presentations of scientific/technological results were presented at key conferences:

1) N. Roxhed, F. Niklaus, "Adhesive Wafer Bonding and Applications", Proc. WaferBond 2009, Grenoble, France. (Keynote Presentation)

2) A. Fischer, "Selective Electroless Nickel Plating on Oxygen-Plasma-Activated Gold Seed Layers for the Fabrication of Low-Contact Resistance Vias and Microstructures" IEEE MEMS, January 2010, Hong Kong

3) F. Niklaus, "Adhesive Wafer Bonding, Applications and Trends", Proc. ECS Wafer Bonding Symposium 2010, Vol.33, No.4, pp.273-286, Las Vegas, USA. (Invited Presentation)

4) A. Elfving, "Low cost, high performance Far Infrared microbolometer", Optical Sensing and Detection Conference, SPIE Photonics Europe, April 2010, Brussels. (Invited Presentation)

5) N. Roxhed, "Low-Cost Uncooled Microbolometers for Thermal Imaging, Optical Sensing and Detection Conference, SPIE Photonics Europe, April 2010, Brussels. (Invited Presentation)

6) A. Fischer, F. Forsberg, M.A. Lapisa, N. Roxhed, G. Stemme, F. Zimmer, F. Niklaus, "Heterogeneous Integration Technologies for Optical MEMS", Proc. IEEE Photonics Society Annual Meeting 2010, pp.487-488, Denver, USA. (Invited Presentation)

7) F. Niklaus, "Quantum-well, silicon-germanium bolometers for low-cost infrared imagers", Proc. MSW 2010, Stockholm, Sweden.

8) G. Stemme, F. Niklaus, "Wafer-Level Heterogeneous Integration Techniques for MEMS and IC", Proc. International Symposium on Integrated Microsystems (ISIM2011), Tsukuba, Japan, 2011. (Invited Presentation)

9) Per Ericsson, Andreas Fisher, Fredrik Forsberg, Niclas Roxhed, Björn Samel, Susan Savage, Göran Stemme, Stanley Wissmar, Olof Öberg, Frank Niklaus, "Towards 17 μm pitch heterogeneously integrated Si/SiGe quantum well bolometer focal plane arrays", Proc. SPIE 2011, pp.801216, Orlando, USA.

10) Fredrik Forsberg, Andreas C. Fischer, Göran Stemme, Niclas Roxhed, Per Ericsson, Björn Samel, Frank Niklaus, "High-Performance Infrared Micro-Bolometer Arrays Manufactured Using Very Large Scale Heterogeneous Integration", IEEE Proc. OMN 2011, pp.9-10, Istanbul, Turkey. (Invited Presentation)

11) Per Ericsson, Linda Höglund, Björn Samel, Susan Savage, Stanley Wissmar, Olof Öberg, Jan-Erik Källhammer, Dick Eriksson, "Design and evaluation of a quantum well based

resistive far infrared bolometer", International European Symposium on Security & Defense, Proc. SPIE 7834, 78340Q, 2010

ICU presented several scientific results during workshops, tutorial courses (12 contributions):

1) F. Niklaus, "Infrared Imaging Components for Use in Automotive Safety Applications", EC FP7 Concertation Meeting – Kick-Off Photonic Projects, Barcelona, Spain, September 2008.

2) F. Niklaus, "Infrared Imaging Components for Use in Automotive Safety Applications (ICU)", ICT 2008 exhibition, Lyon, November 2008. (Booth)

3) F. Niklaus, "3DPlatforms for IC Integrated MEMS" - Cofabrication of MEMS and electronics, Microelectronics Training Center IMEC, December 2008. (Tutorial)

4) D. Eriksson, "Pedestrian Injury Mitigation System", 3th Euripides Forum, Barcelona, October 2009. (Presentation)

5) J. Andersson, "Detector technologies for advanced IR imaging", IMAGIC Seminar Days, Stockholm, Sweden, November 2009. (Presentation)

6) T. Kvisterøy, "Microbolometer arrays in mass production", IMAGIC Seminar Days, Stockholm, Sweden, November 2009. (Presentation)

7) F. Niklaus, "Infrared Imaging Components for Use in Automotive Safety Applications (ICU)" - European Village, SPIE Photonics Europe, April 2010, Brussels. (Booth)

8) ICU was advertised at ICT 2010, Brussels, Belgium (Booth).

9) F. Niklaus, "Heterogeneous 3D Integration Technologies for MEMS and NEMS", Intel Santa Clara, USA, August 2011. (Presentation)

10) F. Niklaus, "Heterogeneous MEMS Integration Technologies", ST Microelectronics, Agrate, Italy, September 2010. (Presentation)

11) Per Ericsson, "Novel solutions for low-cost IR imaging", IMAGIC Seminar Days, Stockholm, Sweden, November 2010. (Presentation)

12) F. Niklaus, G. Stemme, "Heterogeneous 3D Integration and Packaging Technologies for MEMS and NEMS", 12. Chemnitzer Seminar für Nanotechnology, Nanomaterials und Nanorelability, Fraunhofer ENAS, November 2011. (Presentation)

2.3. Dissemination through education

The academic institutes have been very active in supporting the use and exploitation plans for ICU. More particularly efforts were undertaken to align ICU research with PhD research and use ICU technology for training students. VUB has been exposing a large amount of students to ICU related technologies. First in terms of PhD works four PhD students are currently conducting their doctoral research on ICU issues (not financed by ICU):

- *Els Moens (PhD scheduled to end in 2011)*
  Design and manufacturing of an insect-alike compound facet eye
  This PhD student is financed as teaching assistant at the Vrije Universiteit Brussel. The work deals with the design of novel refractive micro-optics by mimicking insect eyes and their integration with infrared cameras (Promoters: H. Ottevaere, H. Thienpont)
- *Keerti Vardham Sharma (PhD scheduled to end in 2012)*
  Novel diffractive optical components for photonic applications
  This PhD student is financed by the Institute for the Promotion of Innovation by Science and Technology in Flanders (IWT). The work deals with the design of novel diffractive optics for industrial applications with a main focus on the automotive. (Promoters: H. Ottevaere, H. Thienpont)
- *Fredrik Forsberg (PhD scheduled to end in 2012)*
  Heterogeneous Integration Technologies for Complex Microsystems
  This PhD student is financed as teaching assistant at KTH Royal Institute of Technology. The work deals with the design of novel heterogeneous integration technologies for complex microsystems such as IR bolometer arrays. (Promoters: F. Niklaus, G. Stemme)
- *Andreas Fischer (PhD scheduled to end in 2012)*
  Via Technologies for Heterogeneous Microsystems
  This PhD student is financed as teaching assistant at KTH Royal Institute of Technology. The work deals with via technologies for heterogeneous integration of microsystems, including through silicon via technologies. (Promoters: F. Niklaus, G. Stemme)

In terms of teaching, ICU technologies were illustrated during the lecture “Microsystem Technology” (course no.: EK2350, Prof. Göran Stemme, Dr. Frank Niklaus) at KTH and during the lectures of H. Thienpont on “Recent Trends in Photonics”. The latter is a compulsory course in the Erasmus Mundus MSc “Masters in Photonics” (http://www.master-photonics.org/) involving VUB, UG, Univ. of St. Andrews (UK), Heriot-Watt Univ. (UK) and KTH (Sweden) and in the joint VUB-UG MSc in Photonics. Also SensoNor exploited the ICU project through open seminars at Vestfold University College in Norway.

VUB also organised at the end of October 2008 a science week for secondary schools in Flanders. This initiative was co-organised by the SPIE Brussels Student Chapter and with 3 shows 550 students and 50 teachers were reached. This was certainly an important event for raising public awareness for and interest in photonic technologies. At this occasion post-doc and PhD students teamed up to explain the optical spectrum and the different applications of each spectral region. In particular they demonstrated to secondary year students the use of infrared technologies and their applications in automotive, in security, in the medical world, and in identifying losses in power grids.

VUB prepared with the Solvay Business Engineering School – Faculty of Economical and Political Sciences a business project on ICU for their course on Entrepreneurship in the academic year 2009-2010 and 2010-2011. The objective of such a business project was to discuss the potential implementation of a given technology in a given market and to estimate its impact on the economy. The project has been mentored by M. Goldschtein and T. Guldemont (Faculty of Economical and Political Sciences) and H. Ottevaere (Faculty of Engineering Sciences) at VUB. The market chosen for this business project is the field of security and the following applications have been investigated: Perimeter Detection and Logistics. For both applications the competitors on the

market, the technical approach and the value chain have been investigated. Contacts have been taken with companies that develop today already sensing modules for these applications.

VUB also organized at the end of November 2011 a science week for secondary schools in Flanders. This initiative was co-organised by the SPIE Brussels Student Chapter and with 5 shows more than 500 students and 30 teachers were reached. This was certainly an important event for raising public awareness for, and interest in photonic technologies. At this occasion post-doc and PhD students teamed up to explain the optical spectrum and the different applications of each spectral region. In particular they demonstrated to secondary year students the use of infrared technologies and their applications in automotive, in security, in the medical world, and in identifying losses in power grids.

2.4. Dissemination through press releases

A considerable effort was conducted in terms of widespread distribution of press releases. The early press releases were reported already in D8.2. In the table below we summarize references to ICU found on the internet, excluding ICU releases on website linked to one of the partners. This result evidences that ICU has been mentioned on leading technical websites.

Organisation	Website
Optics.org	http://optics.org/cws/article/industry/34885
Newsdesk	http://www.newsdesk.se/pressroom/acreo/pressrelease/view/europe-joins-rd-forces-to-develop-low-cost-infrared-night-vision-system-for-the-automotive-reducing-the-number-of-accidents-on-the-road-226011
I-Micronews	http://www.imicronews.com/interview.asp?id=36 http://www.imicronews.com/lectureArticle.asp?id=1760
Evertiq	http://www.evertiq.se/news/read.do?news=15702&cat=1
Laser Focus World	http://www.laserfocusworld.com/articlePagedList.html?publicationId=92&catId=Feats http://www.laserfocusworld.com/issue/toc.html?volumeNumber=15&issueNumber=14&publicationId=92 http://www.laserfocusworld.com/display_article/338733/12/ARTCL/none/IndRe/IMAGING-&-DETECTOR-INDUSTRY-REPORT?dcmp=rss
Photonics Newsletter, European Commission	http://cordis.europa.eu/fp7/ict/photonics/home_en.html
Photonics.com	http://www.photonics.com/Content/ReadArticle.aspx?ArticleID=34720
SPIE.org	http://spie.org/Documents/ConferencesExhibitions/Ronan-Burgess-SPIE-Europe-Photonics%20Europe-2008.pdf
Photonic Products	http://blog.photonic-products.com/category/laser-news-and-laser-related-news/infrared-laser-news/
Infrared Imaging News	http://www.maxtech-intl.com/irnews.htm (Vol. 14, No.12, December 2008)

Table: ICU related information releases spotted on the internet

ICU also submitted an abstract for publication in the EOS brochure "How optics and photonics address Europe's challenges of the 21st century". This brochure will demonstrate to politicians and the broad public how photonics address Europe's challenges in the 21st century by providing solutions for the fields of health, energy, environment, production, IT, security and transport. An EOS jury selected ICU as one of the best contributions for publication in the printed brochure. In addition, all accepted contributions were also published in a web gallery at www.myeos.org. Both the brochure and the web gallery were published in summer 2010 and were widely promoted in the European optics and photonics community.

VUB took the lead in the production of a short promotional video of ICU. Key partners in ICU have been interviewed and demonstration material has been filmed at the European Network Village at SPIE Photonics Europe 2010. This video have been made available through the B-PHOT website

www.b-phot.org and on the ICU website. B-PHOT is the new name for the research group of VUB involved in ICU. The video is edited by Mad Monkey Studios that provide video productions for not for profit organisations (www.madmonkey.be).

3. Conclusions

This report evidences the continued commitment of all ICU partners to exploit the generated foreground knowledge to the best of their abilities. Dissemination have been drafted both by the academic partners and by the companies. After 40 months of project research: **three journal papers** and **one chapter in a book** were published; ICU has been made visible at major events in the field with **7 invited and 4 contributed presentations – 3 exhibit booths** were organized as well. Finally ICU also disseminated through **press releases and a promotional movie**.