

**ACADEMIC SENATE  
of  
CALIFORNIA POLYTECHNIC STATE UNIVERSITY  
San Luis Obispo, CA**

**AS-762-13**

**RESOLUTION ON PROPOSED NEW DEGREE PROGRAM FOR MASTER OF  
SCIENCE IN PRINTED ELECTRONICS AND FUNCTIONAL IMAGING**

- 1 WHEREAS, There is an emerging field in functional printing comprising printed electronics, security  
2 printing, active packaging, and additive manufacturing, projected to grow substantially in  
3 the next several decades; and  
4
- 5 WHEREAS, Functional printing uses conventional and emerging printing techniques, many of which  
6 are already in place in the Graphic Communication Department, to produce new  
7 electronic devices, security features, and functional packaging; and  
8
- 9 WHEREAS, The graphic communication industry stands ready to support the Master's degree  
10 program with advanced laboratory technology to further Cal Poly's Learn by Doing  
11 pedagogy; and  
12
- 13 WHEREAS, The Graphic Communication Department has taught undergraduate coursework in  
14 printing and imaging for more than sixty years and can leverage that expertise in graduate  
15 education; and  
16
- 17 WHEREAS, Cal Poly's Graphic Communication Department is considered one of the leading  
18 institutions in the country for undergraduate education in graphic communication; and  
19
- 20 WHEREAS, The Graphic Communication Department is proposing a Master of Science degree in  
21 Printed Electronics and Functional Imaging, comprised of online and face-to-face  
22 coursework culminating in scholarly research projects; and  
23
- 24 WHEREAS, The College of Liberal Arts Curriculum Committee and the Academic Senate Curriculum  
25 Committee have carefully evaluated this proposal and recommend its approval; therefore  
26 be it  
27
- 28 RESOLVED: That the Academic Senate of Cal Poly approve the proposal for the Master of Science in  
29 Printed Electronics and Functional Imaging and that the proposal be sent to the  
30 Chancellor's Office for final approval.

Proposed by: Academic Senate Curriculum Committee  
Date: April 9 2013

Cal Poly, San Luis Obispo

Summary Statement of Proposed New Degree Program in  
Printed Electronics & Functional Imaging  
for CSU Academic Master Plan Projection

1. **Title of proposed program:**

Master of Science in Printed Electronics and Functional Imaging

2. **Reason for proposing the program:**

Functional Printing encompasses academic coursework related to several emerging graphic communication applications: *Printed Electronics*, which Das and Harrop (2011) project to grow from a \$2.2 billion today into a \$44.25 billion industry over the next decade; *Active and Intelligent Packaging*, projected by Research and Markets (2011) to grow to \$23 billion per year over the next decade; and *Security Printing*. The European research institute PIRA predicts the global market for brand protection to reach a value of more than \$11.4 billion by 2014 (Mc Loone, 2010). Further, other additive manufacturing areas, including 3D printing, are gaining in popularity.

These fields involve the application of specialty inks to produce functional and optical devices including a number of new high-tech printing applications. Active packaging focuses on printed packaging that improves shelf life or enhances supply-chain tracking. Anti-counterfeiting is critical for brand protection. Using both conductive and insulating inks, printed electronics and functional imaging offer low-cost production of displays, lighting and energy harvesting devices on flexible substrates.

The Master of Science in Printed Electronics and Functional Imaging will prepare graduates for conceptual and practical electronic or functional applications, advanced research, and the development of intellectual property related to the use of printing and coating technologies in these emerging fields. This Master of Science degree integrates well with the undergraduate Graphic Communication degree offered at Cal Poly, which largely focuses on graphic printing and imaging technologies. The Master of Science degree engages students in critical thinking and conducting seminal research using the department's significant capital assets. The degree will further enhance the department's relationship with industry, allowing students to engage immediately with leading industry professionals. This program will leverage the strengths of the undergraduate program while developing increased research opportunities in the department.

This degree is offered as a self-support program under CSU Executive Order No. 1047.

3. **Expected student learning outcomes and methods for assessing outcomes:**

SLO	Assessment
Analyze the theoretical foundations underpinning conductive materials, optical patterning, basic electronic components and circuits, and material behavior.	Graduate faculty will assess theoretical foundations through projects produced in GrC 530 as well as the literature reviews associated with GrC 596 using custom evaluation rubric.
Integrate graphic design, functional design, and creative applications into expressive technologies (technologies that enhance human interaction) through compelling products.	Graduate faculty will assess graphic and functional integration through projects produced in GrC 530 and research projects in GrC 596 using custom evaluation rubric.
Effectively present and defend scholarly research methodologies, findings, and implications in written form.	Graduate faculty will assess writing skills as demonstrated through the students written summative research project paper using custom evaluation rubric.

Evaluate and determine the suitability for printing as a production method for specific functional and novel products.	Graduate faculty will assess evaluation ability for suitability of printing through a summative paper in GrC 530 using custom evaluation rubric.
Develop specifications and tolerances for deposition technologies for various functional products.	Graduate faculty will assess specifications and tolerance development through summative paper in GrC 530 using custom evaluation rubric.
Demonstrate knowledge related to microscale patterning and deposition including accurately measuring patterning and deposition characteristics using a variety of instruments.	Graduate faculty will assess microscale patterning and deposition through practical evaluation in GrC 530 using custom evaluation rubric.
Analyze multiple equipment technologies against required specifications and tolerances and determine appropriateness or equipment modifications required.	Graduate faculty will assess equipment technology analysis through summative paper in GrC 530 using custom evaluation rubric.
Evaluate fundamental business concepts related to starting and managing an entrepreneurial operation.	Graduate faculty will assess fundamental business concepts via a business plan developed in GrC 520 using custom evaluation rubric.
Effectively present and defend scholarly research methodologies, findings, and implications orally.	Graduate faculty will assess oral communication of scholarly research during presentation in GrC 596 using custom evaluation rubric.

**4. Anticipated student demand:**

	<b>Number of Students</b>		
	<u>at initiation</u>	<u>3 years after initiation</u>	<u>5 years after initiation</u>
Number of Majors	10-15	20-30	30-45
Number of Graduates (cumulative)	0	20	50

A comprehensive online survey was conducted by contacting professors from around the world who may have undergraduate students interested in this type of degree program. Additionally, GrC alumni were contacted using a variety of email lists and alumni groups. Here are some key results:

- 375 individuals completed all or most of the survey
- Of those who participated, 275 were current undergraduates and 83 had completed their bachelor's degree.
- 235 survey respondents were likely, very likely, or planning on pursuing a graduate degree in the next five years.
- 167 survey respondents expressed interest in Cal Poly's proposed graduate program in Printed Electronics and Functional Imaging.
- Of those, 118 individuals provided contact information and requested more information about the proposed degree program.

**5. If additional resources (faculty student allocations, support staff, facilities, equipment, etc.) will be required, please identify the resources, indicate the extent of the college's commitment**

to allocate them, and evidence that college decision-making committees were aware of the source of resource support when they endorsed the proposal. If the college expects the University to provide additional resources, please identify the resources and anticipated cost: On startup, the degree program will use existing Graphic Communication Department laboratories, equipment, and staffing. Existing faculty will teach on an overload basis through Extended Education. As a self-support program, success may afford opportunity to add faculty to the GrC staff in the future. As additional resources become available through strong enrollments, faculty and equipment may be acquired. Additionally, the Graphic Communication Department has a strong record of development by in-kind donations, grant funding, and endowments, which will be used to strengthen the financial undergirding.

**6. If the program is occupational or professional, summarize evidence of need for graduates with this specific educational background:**

At the Printed Electronics USA 2011 conference November 30-December 1 in Santa Clara, CA, seventeen employers were asked the following questions:

1. Within the next five years, do you expect to hire employees in your company who help you develop, improve, or scale your production system(s)?

*All survey respondents indicated they will be hiring in the next five years.*

2. If yes, could you see hiring an individual with a Master's of Science degree who...
  - Generally understands deposition and patterning systems for printed electronics, smart packaging, and security printing.
  - Can measure, analyze, and optimize key variables in printing technologies
  - Can measure analyze, and optimize web handling systems
  - Can measure, analyze, and optimize material/ink compositions
  - Can measure, analyze, and optimize morphologies (ink film surfaces)
  - Can measure, analyze, and optimize drying/annealing systems
  - And knows the issues related to scaling reproduction systems for commercial applications?

*Sixteen of seventeen (94%) indicated they could see hiring an individual with this particular background in the next five years.*

There were more than 1200 attendees at the Printed Electronics USA 2011, an increase of 250 attendees from the previous year. Cal Poly's proximity to the Silicon Valley is critical, as many of the companies in this space stem from conventional electronics and are looking for the opportunity to develop new products and improve manufacturing techniques.

**7. If the new program is currently a concentration or specialization, include a brief rationale for conversion:**

Printed Electronics and Functional Imaging is not currently a concentration or specialization.

**8. If the new program is not commonly offered as a bachelor's or master's degree, provide compelling rationale explaining how the proposed subject area constitutes a coherent, integrated degree major which has potential value for students. If the new program does not appear to conform to the CSU trustee policy calling for "broadly based programs," provide rationale:**

The program is a natural extension of the Graphic Communication undergraduate degree. However, it has broad appeal to students with complimentary undergraduate degrees as well, including but not limited to: Business, Graphic Design, Physics, Chemistry, Packaging, Electrical Engineering, Materials Engineering, and Mechanical Engineering. This degree will provide a coherent path into a

specialized application area for broader undergraduate degrees. While this degree may not technically qualify as a “broadly based program,” it is designed to touch on various applications of functional printing, including printed electronics, active packaging, security printing, 3D printing, and other functional print manufacturing. These emerging applications have broad interest and will shape society into the future.

**9. Briefly describe how the new program fits with the mission and/or strategic plan for the department, college and/or university:**

This degree program fits well with the Graphic Communication mission by focusing on research and discovery. The degree program leverages the equipment base along with research interests of faculty to extend the scholarship of the department and further its influence in shaping graphic communication technology. The College of Liberal Arts offers diverse, significant curricula. This program strengthens the college’s unique role in anticipating the future and defining it in light of human experience. With a focus on deployment, this degree addresses the human experience and how laboratory research can be scaled to impact the broader population. This Master’s of Science degree is focused on technology development and deployment in the context of advanced printed materials. It serves to directly meet the STEM objectives of the university as well as the college and department.

**10. Attach a display of curriculum requirements:**

**COURSEWORK (45 Units)**

Core Courses (29 units)

GrC 501 – Survey of Functional Printing .....	2.0
GrC 502 - Orientation to Functional Printing (Prereq or co-req GrC 501).....	2.0
GrC 510 – Materials for Functional Printing (Prereq or co-req GrC 501).....	4.0
GrC 512 – Printing and Coating Tech (Prereq or co-req GrC 501).....	4.0
GrC 514 – Imaging for Electronics & Functional Printing (Prereq or co-req GrC 501) .....	4.0
GrC 520 – Functional Printing Product and Business Development (Prereq GrC 512 OR GrC 514).....	4.0
GrC 530 – Functional Printing Workflows (Prereq GrC 502 AND GrC 512 AND GrC 514).....	4.0
GrC 560 – Grad Research Methods in Printed Electronics & Functional Imaging (Prereq GrC 530) .....	2.0
GrC 596 – Research Project in Printed Electronics and Functional Imaging (Prereq GrC 560) .....	3.0
<b>Subtotal (core).....</b>	<b>29.0</b>

Approved Electives (16 units)

*Select 16 units from the following:*

GrC 500 – Special Problems in GrC (Prereq Graduate standing and consent of instructor) .....	2.0
GrC 551 – Current Trends in Printed Electronics (May be repeated for up to 12 units, Prereq GrC 502) .....	4.0
GrC 552 – Current Trends in Active Packaging (May be repeated for up to 12 units, Prereq GrC 502) .....	4.0
GrC 553 – Current Trends in Security & Anti-counterfeiting (May be repeated for up to 12 units, Prereq GrC 502).....	4.0
GrC 595 – Cooperative Experience Education (Prereq Graduate standing and consent of instructor) .....	12.0
Other courses as approved by academic advisor .....	8.0
<b>Subtotal (electives - select 16 units).....</b>	<b>16.0</b>

**TOTAL..... 45.0**

State of California  
**M e m o r a n d u m**

**CAL POLY**  
SAN LUIS OBISPO

**To:** Steven Rein  
Chair, Academic Senate

**Date:** July 3, 2013

**From:**   
Jeffrey D. Armstrong  
President

**Copies:** K. Enz Finken  
M. Pedersen  
D. Epperson  
D. Valencia-Laver

**Subject:** Response to Academic Senate Resolution AS-762-13  
Resolution on Proposed New Degree Program: Master of Science in Printed Electronics  
and Functional Imaging

---

I am pleased to approve the above-entitled Academic Senate resolution. The Associate Vice Provost for Programs and Planning is hereby directed to proceed with implementing this resolution.

Please express my appreciation to the members of the Academic Senate for their attention to this important curricular matter.