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World-Leading Technology

NTU-Developed Millimeter-Wave IC Technology Used in Radio Telescope Array

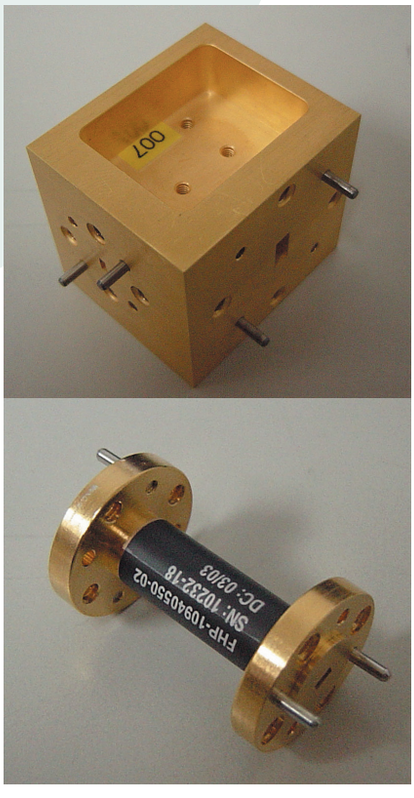
The Program for Promoting Academic Excellence of Universities jointly implemented by the NSC and Ministry of Education continues to yield outstanding results, including millimeter-wave technologies developed by a team of researchers at the National Taiwan University (NTU). Three papers written by this team concerning its integrated circuit (IC) design technology have been accepted for presentation at the "International Solid-State Circuits Conference" (ISSCC) in February 2005 – showing the international credibility that the team has earned.

According to Prof. Wang Huei of the NTU Department of Electrical Engineering and Graduate Institute of Communication Engineering, the millimeter-wave (30 - 300 GHz) frequency band offers the advantages of improved antenna performance, larger bandwidth, greater information-carrying capacity, and smaller circuit size over the conventional microwave band (0.3 - 30 GHz). Millimeter-wave radiation additionally suffers less attenuation in poor weather conditions than infrared and visible light. The NTU team's "Advanced Microwave and Millimeter-Wave Technologies" project has recently completed the design of millimeter-wave IC chips for the 30 - 110 GHz band. This frequency band includes the 60-GHz frequency that will be used in new-generation wireless LAN (WLAN); 60-GHz WLAN promises to improve existing transmission speeds (~50 Mbps) provided by 2.4 and 5.2-GHz WLAN by ten or twenty times (up to 1 Gbps). Almost no research (especially academic research) had been performed on millimeter-wave in Taiwan prior to this project. Thus far the team has used the Gallium Arsenide (GaAs) process to complete an advanced 60-GHz integrated single-chip receiver incorporating an antenna, a mixer, a transition, and a local oscillator.

The team has also cooperated with the Taiwan Semiconductor Manufacturing Company (TSMC) to design millimeter-wave chips using an integrated CMOS process far less expensive than the GaAs processes. They have already completed the world's highest frequency (60-GHz) CMOS oscillator. Prof. Wang has stated that the NTU team and TSMC also developed a 113-GHz oscillator and a DC-to-80-GHz broadband amplifier using 130-nm and 90-nm silicon processes. These research results imply sharp future reductions in the cost of millimeter-wave chips and elements, and will stimulate more research on civilian applications of millimeter-wave technology and accelerate the full-scale integration of wireless broadband in everyday life.

Apart from the development of millimeter-wave chips, the team has also helped the NTU Department of Physics and the Academia Sinica Institute of Astronomy to establish the "Array of Microwave Background Anisotropy" (AMiBA) radio telescope array used for exploring the cosmic background radiation at 85 - 105 GHz, and has developed important elements such as mixers and filters for this project. The AMiBA project has chosen to investigate the 85 - 105 GHz frequency band because it will allow the verification of findings from other telescopes at different frequencies and also enable detection of extremely tiny variations in the cosmic background radiation.

Furthermore, the technology developed by the team also encompasses frequency bands used by communications satellites (Ka-band, ~30 GHz), auto radar (77 GHz), and broadband fiber-optic communications. The technology will facilitate the domestic development of key elements needed in satellite communications payloads, auto radar, and fiber-optic communications systems. Finally, since the millimeter-wave band has long been important in military applications, the new R&D results will have a profound impact on both civilian and military electronics industries.



Mixer (above) and filter (below) used in AMiBA radio telescope.

Science Park Sales Set New Record

HSP Firms' Sales Revenue and Paid-in Capital both Surpass NT$1 Trillion in 2004

After a year of recovery for the semiconductor market, many international market survey organizations are now issuing more modest economic forecasts. Semiconductor Industry Association (SIA) statistics state that global semiconductor sales were approximately US$19 billion in November 2004, and this figure was respectively 1.3% and 18% higher than that during October 2004 and November 2003 – suggesting that growth is leveling off. In spite of the tepid economic trend, business indicators at the Hsinchu Science Park (HSP) are still robust: Survey data indicates that HSP firms had an output value of NT$1.2 trillion in 2003 (including both oversea and domestic sales) and are on track to set a new record in 2004.

There were a total of 381 high-tech firms (including one firm not within the park's six major industries) in the HSP as of the end of November 2004, and 113,519 persons were employed in the HSP – an increase of 12,339 or 12% over the same period of the previous year. Paid-in capital of HSP firms had reached NT$1.07 trillion as of the end of October 2004, and this figure was up by 10% from the previous one-year period. The following is an overview of HSP firms' sales revenue, import/export trade, and investment.

Turning first to sales revenue, according to the Hsinchu Science Park Administration, the HSP's high-tech firms enjoyed sales revenue of NT$ 913 billion from January to October of 2004, and this figure represents impressive 34% growth relative to the same period of the previous year. It is projected that HSP firms' sales revenue and paid-in capital both surpassed the NT$1 trillion milestone in 2004. The sales revenue of the HSP's six major industries all climbed during the year. In particular, the precision machinery industry's sales revenue grew dramatically by 62% due to 169% growth in semiconductor and TFT-LCD equipment output value. In second place, the optoelectronics industry also grew strongly by 54% on the back of an 88% increase in flat panel display output value. The biotechnology industry's 39% sales revenue growth was sufficient to put it in third place. The integrated circuit industry – HSP's largest industry – had sales revenue of NT$626 billion from January to October; this figure accounted for 68.6% of the HSP's total sales during the same period and represented growth of 39% from the same period of 2003. Within the IC industry, the IC design and chip manufacturing industry subcategories enjoyed sales revenue of NT$139 billion and NT$428 billion respectively, and these figures were up by 30% and 42% respectively over the previous year. The computers and peripherals industry – HSP's second largest industry – had sales of NT$114 billion, which accounted for 12.5% and was up by 8% over the same period of 2003. The communications industry's sales revenue of NT$50.2 billion was up by 14% over the same period of the previous year. See the table below for a summary of sales revenue growth for the HSP's six major industries.

As for import/export value, HSP Administration statistics indicate that HSP firms engaged in import/export trade worth a total of NT$810 billion from January to November of 2004, and this figure was up by 47% over the same period 2003. Total exports of NT$457 billion and imports of NT$353 billion were up by 29% and 79% respectively from the year before. It should be noted that there were some changes in the HSP's five leading export recipients and their relative shares of HSP exports from January to November 2004. While the five leading export recipients for the year were Hong Kong (20%), China (20%), Japan (12%), the US (11%), and Korea (9%), China and Hong Kong accounted for a respective 23% and 19% of HSP exports during November – making China the largest HSP export recipient. Exports to China and Hong

Sales Revenue of the HSP's Six Major Industries, Jan. - Oct. 2004

Units: NT$100 million

Industry	Jan. - Oct. 2004		Jan. - Oct. 2003		Growth rate (%)
	No. of firms	Sales revenue	No. of firms	Sales revenue	
Integrated circuits	161	6,263	148	4,517	39
Computers and peripherals	57	1,144	58	1,057	8
Communications	53	502	56	441	14
Optoelectronics	60	1,119	58	725	54
Precision machinery	21	73	18	45	62
Biotechnology	28	20	22	14	39
Total	380	9,121	360	6,799	34

Source: Investment Section, Science Park Administration.

Kong grew by 65% and 4% respectively over 2003, and together account for 42% of HSP exports. As far as imports were concerned, the five most important import sources from January to November of 2004 were, in order, Japan (36%), the US (21%), Singapore (8%), Hong Kong (6%), and Korea (3%).

With regard to investments and capitalization increases by HSP firms from January to November of 2004, according the HSP Administration, the strong revival of the global semiconductor market in 2004 lent strong impetus to the HSP's investment recruiting efforts. Among the 43 new startup companies acquired between January and November of 2004 were 18 integrated circuit firms, 11 optoelectronics firms, three communications, computers and precision machinery firms respectively, two biotech firms, and three science park enterprises. Total approved capital was NT$41.8 billion during the period, and this figure was up by 66% over the same period of 2003. Fifty-three existing HSP firms applied to increase capitalization and the approved increase was approximately NT$71.0 billion, which represented growth of 29% over 2003. Total new investment and increased capitalization amounted to NT$112 billion, and this figure was up by 40% over 2003.

Speed-Surfing on Light Paths

Taiwan Joins Global Demonstration of Multi-Stream HDTV at APAN Conference

One of the highlights at the 19th Asia-Pacific Advanced Network (APAN) conference in Bangkok was a demonstration of a global optical network spanning Europe, Asia, and North America totaling 40,000 km in distance. On January 27, the National Center for High-Performance Computing (NCHC) joined three other countries in presenting the power of User Controlled LightPath (UCLP) software for achieving such an impressive feat. Bypassing many devices and using only a few along the path, network engineers in Canada, Taiwan, Korea, Spain and Bangkok used UCLP to link up and deliver multi-stream HDTV. It was a first in cooperative networking, both in the great expanse achieved and the successful delivery of sharp, crisp images in multiple streams. This is a repeat performance for the NCHC. In March 2004, Bill St. Arnaud from CANARIE of Canada coordinated a similar event by linking up Canada's advanced research network CA*net4, Ireland's HEAnet, and the NCHC in Taiwan, and successfully held a videoconference involving five sites across three continents. That collaborative effort, proposed by NCHC's Eugene Yeh and spearheaded by St. Arnaud, also garnered international recognition for the NCHC.

The NCHC's new 20 Gbps-backbone "TaiWan Advanced Research and Education Network" (TWAREN) was a prominent presence at the APAN conference. TWAREN project leader Eugene Yeh gave a presentation on the progress and future direction of this national research network, which began production operation in January of 2004. Also highlighted in his presentation was TWAREN's twin project, the "Knowledge Innovation National Grid" (KING). The two complementary projects are funded by a special grant from the government to stimulate scientific discoveries and foster innovation.

The UCLP technology employed at both events allows a network engineer at a single terminal to control, configure and set up light paths as desired. Jointly developed by CANARIE of Canada and Cisco Canada, UCLP software is gaining popularity for controlling light paths in optical networks. With it, a network user can easily and quickly reach his destination by manipulating the bandwidth and the route to take. Besides Canada's CA*net4, many institutions took part in developing this software, including the Canadian Communications Research Center (CRC), Ottawa University, Waterloo University, and the University of Quebec at Montreal. This ongoing effort is now joined by several international partners – Taiwan's NCHC, Korea's Institute of Science and Technology Information (KISTI), and Spain's i2CAT Foundation – all of whom collaborated in the successful demonstration.

APAN is a non-profit consortium established in 1997 with the initial aim of providing an advanced networking environment for the development and applications of next-generation network technologies. It has since expanded to a global scale, both in connectivity and in collaborative research. APAN members consist of economies in Asia-Pacific and Oceania, with Japan, Korea, Singapore, Taiwan, China, Malaysia, and Australia as early members. The consortium has since adopted a more lenient membership requirement and has now expanded to include Hong Kong, Thailand, India, Bangladesh, Philippines, New Zealand and Sri Lanka. The NCHC and Academia Sinica joined APAN in 2001 as the APAN-TW Consortium. Both organizations have since been very active in APAN and made significant contributions.

The demonstration conducted at the APAN conference showed that it is possible for realtime, high-definition television to be broadcasted by content providers. Emergency news images and information can be transmitted around the world by quickly establishing the necessary lightpaths. Even more impressive, a connection between Taiwan and any destination (or endpoint) in the world is only one hop away. Scientists collaborating with peers around the world can be trained on UCLP software for the direct transport of data, regardless of the length

of the lightpath. This service will soon be available to endusers as the software becomes more mature.

The NCHC will continue to pursue international collaborations and form alliances with networks and research institutions around the world. By laying the foundation for Taiwan to become a hub of knowledge industry in the Asia Pacific, the NCHC is doing its part to help the nation increase and sustain its global competitiveness.

A Great Achievement in High-Energy Physics

NTU Physics Team Finds Direct Evidence of CP Violation

Taiwan's high-energy physics researchers have recently made many world-class discoveries. With funding from the NSC, a research team from Taiwan participating in Japan's Belle experiment on charge-parity (CP) violations succeeded in measuring a "direct CP violation" in a B meson system last year. The Belle collaboration, which works at the so-called "B factory" accelerator, has further detected inconsistencies in CP violation. These inconsistencies have been confirmed by the BaBar collaboration at the Stanford Linear Accelerator Center in California and may point the way to new physics.

At an NSC press conference on January 27, team member Associate Professor Chang Paoti noted that the parity violation hypothesized by Lee Tsung-dao and Yang Chen-ning had been observed by Wu Chien-shiung *et al*. as early as 1957. Scientists later found cases of "direct" and "indirect" CP violations in K meson systems, but since direct CP violations are so small (1,000 times less common than indirect CP violations), it was not confirmed until 35 years later.

The so-called Standard Model tells physicists that although CP violation is tiny in K meson systems, it may be very large in B meson systems. CP violation is an extremely interesting phenomenon that can explain the difference between matter and antimatter, but the physical characteristics of B mesons were little known twenty years ago. To explore the mysteries of CP violation among B mesons, Japan's High Energy Accelerator Research Organization (KEK) and the Stanford Linear Accelerator Center both spent several hundred million dollars in the early 1990's to build "B factories" capable of mass-producing B mesons. Taiwan later joined Japan's Belle experiment in 1994.

Prof. Chang explained that in 2001, both the Belle and BaBar experiments indisputably detected CP violation among B mesons and experimentally verified that these were indirect CP violations. The existence of direct CP violation among B mesons was confirmed later and became one of the most important findings in high-energy physics in 2004. Although BaBar announced detection of direct CP violation roughly two weeks ahead of Belle, Belle's measurements were more accurate. Taiwan's high-energy physics research team had played a major role in its findings. Five members of the Taiwan team made presentations on behalf of Belle at the 2004 International Conference on High Energy Physics in Beijing, and other Belle participants reported on the findings of the Taiwan team. The Belle experiment has published approximately 105 papers to date, and the Taiwan team was in charge of 22 of those papers.

Members of Taiwan team at the 32nd International Conference on High Energy Physics in Beijing.

The Taiwan team has also submitted five papers to physics journals and is responsible for another five papers currently under Belle's review. It is evident that Taiwan has had a big hand in recent high-energy physics breakthroughs.

Founded in 1994 by NTU Prof. Hou Wei-shu, Taiwan's Belle team has gradually grown from a small four-member team to a large group of over 20 researchers. In particular, the enlistment of Prof. Bob Yee Hsiung – discoverer of direct CP violation among K mesons – has boosted the team's caliber and broadened its research scope. The highly competitive team is regarded as major force in the study of CP violation and B meson physics. The team will continue to research CP violation in the future, particularly in the search for new physics phenomena. The team also looks forward to greater achievements as it gradually moves up to Large Hadron Collider experiments involving more personnel and greater challenges.

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