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In this issue

Technology Developed in GICE

Uneven illumination removal and image enhancement using Empirical Mode decomposition

from Communication and Signal Processing Group

Uneven light distribution problems often arise in poorly scanned text or text-photo images and natural images taken by digital camera. With the digitization of scientific and technological products in recent years, more and more devices need image processing skill, including digital still cameras (DSC), cell-phones, projectors, printers, liquid crystal TVs, LCDs, video presentation systems (VPS), etc. All of these devices need to show good-looking images. The DSCs are used to take pictures just like conventional film cameras. People prefer digital cameras over traditional cameras for their convenience. However, in many situations, the cameras are unable to work well in darker environments or with uneven light sources. Figure 1(a) shows an example of color image with a shadow on its right side and the source luminance on the left side. We would like to make this image more pleasing by applying image processing techniques.

With the development of computer technology and the internet, we often want to digitize our documents to facilitate their storage and distribution by using a scanner. However, poorly scanned text and text-photo images like those demonstrated in Figs. 1(b) and 1(c) are often encountered. Due to the uneven light distributions (LDs) shown in Figs. 1(b) and 1(c), we cannot see the details clearly, and it is difficult to read the text in the shadow of the images.

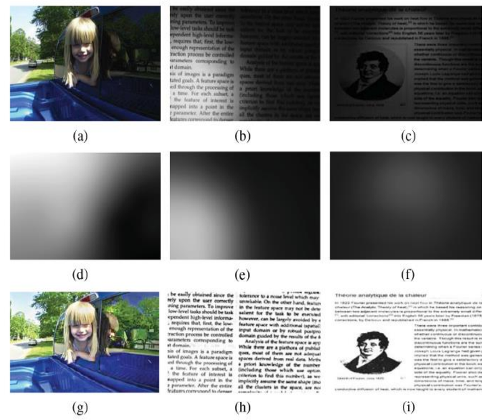

Fig. 1 First row: Images with uneven illumination. (a) Natural color image. (b) Text image. (c) Text-pho image. Second row: (d) (e) (f) are the estimated light distribution (LD) by line-based empirical mo decomposition (LBEMD) for (a), (b), and (c), respectively. Third row: (g) (h) (i) are the enhanced imag by LBEMD for (a), (b), and (c), respectively.

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GICE Honors

Prof. Ruey-Beei Wu
The 57th Academic Award by the Minitry of Education

Prof. Huei Wang
2013 Asia-Pacific Microwave Conference (APMC)
Best Paper Award

Prof. Tzong-Lin Wu
2013 IEEE 22nd Conference on Electrical Performance of Electronic Packaging and Systems
Best Poster Paper Award

Message from the Director

Tzong-Lin Wu

Professor & GICE Director

Dear Colleagues and Friends,

Two outstanding professors of GICE share their recent research outcome in the first issue of 2014 GICE Newsletter. Prof. Soo-Chang Pei in Communication and Signal Processing group developed a novel Empirical Mode Decomposition method to enhance the image quality with uneven illumination. This method could be widely applied to text or text-photo images. Prof. Ruey-Beei Wu in Electromagnetic Wave group demonstrates the new compensation technology for the signal integrity on TSV-based 3-D IC. This new idea could be adopted in next generation computing and communication systems.

This issue is quite rich and informative. Please have a cup of coffee or tea, and enjoy the reading of GICE Newsletter!

Technology *(continued from page 1)*

An innovative image-processing technique for uneven illumination removal using empirical mode decomposition (EMD) [1] is proposed. The EMD is local, adaptive, and useful for analyzing nonlinear and nonstationary signals. In this article, we decompose images by proposed line-based EMD (LBEMD) method and get the background level locally and adaptively. This algorithm can enhance the local reflectance in the image while removing uneven illumination for black/white text images, text-photo images, and natural color/graylevel images.

LBEMD method for text and text-photo images processing

Figure 2 demonstrates the flow chart of LBEMD for text and text-photo images. We first use LBEMD to find column-wise residual image and row-wise residual image. These two residual images are averaged and divided by 2 to get the final residual image. The residual image can be seen as the background light distribution. We divide original text or text-photo image by this residual image in order to remove the shadow. It can be seen from figure 3 to 4 that LBEMD removes the uneven illumination and shadow effectively. The gain control parameter α is used to adjust the darkness of text in the enhanced images.

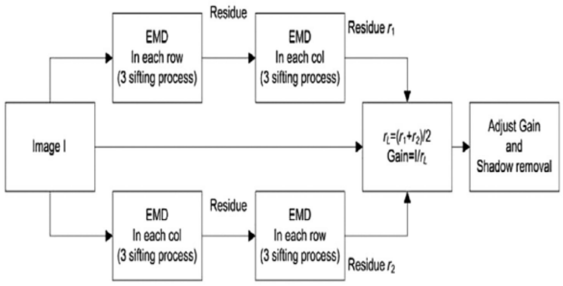

Fig. 2 The processing flow diagram of LBEMD for text and text-photo images.

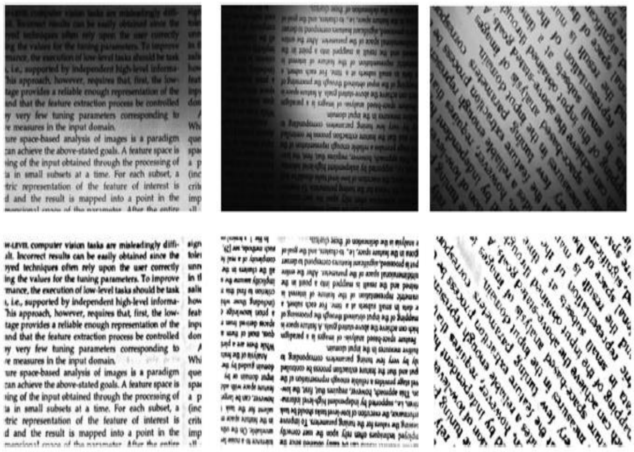

Fig. 3 First row: Text images with uneven illumination. Second row: Uneven illumination removal with proposed LBEMD method.

Figure 5 demonstrates the flow chart of LBEMD for natural color and gray-level images. We use a different algorithm to estimate the residual images (background light distributions) of color and gray-level images. The estimated light distributions are divided by original image and therefore we can do shadow removal of images.

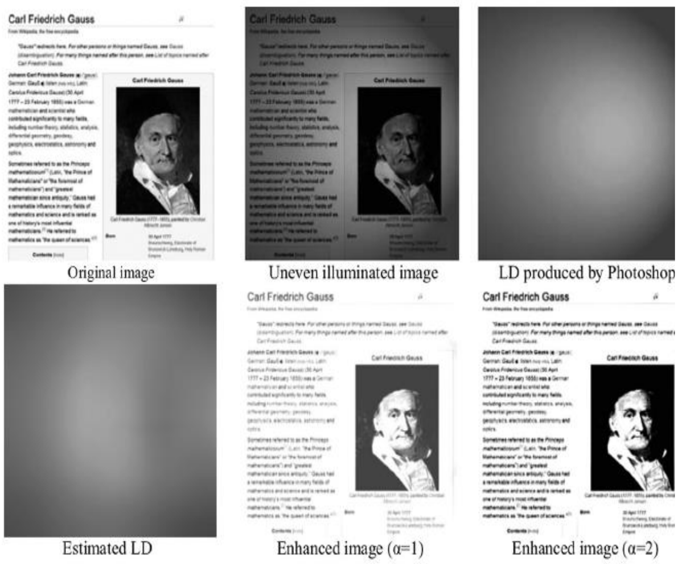

Fig. 4 Original image, uneven illuminated image, LD produced by Photoshop, estimated LD, ; enhanced images by LBEMD. Peak signal-to-noise ratio (PSNR) is 17.03 dB for $\alpha = 1$ and 19.99 for $\alpha = 2$.

LBEMD method for natural color and gray-level images processing

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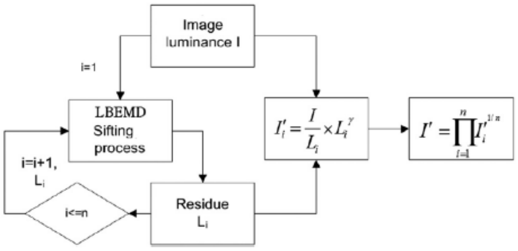

Fig. 5 The processing flow diagram of LBEMD for natural color/gray-level images.

As figure 6 and 7 shows, the shadow parts of color and gray-level images are removed and the hidden details can be seen clearly after processing by using LBEMD.

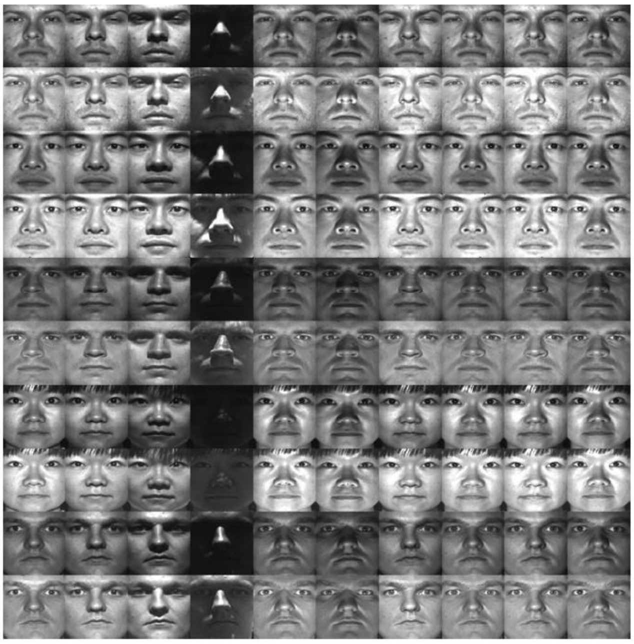

Fig. 6 Comparison of face images under uneven illuminations (in odd rows) with the uneven illuminations removed images (in even rows) using LBEMD. Only parts of the results (five subjects each seen under ten viewing conditions) are shown because of the space limitation.

LBEMD method for color constancy

Color constancy [2] is often required in many image processing fields, such as computer vision, image enhancement, pattern recognition, etc. There are numerous color constancy approaches proposed in the literature. All of them suppose that there is only a single light source and the light color is spatially uniform across the scene. The color of the scene illumination is first estimated and then the original image will be color-corrected by the Von Kries model [3]. The two most widely used groups of illuminant estimation approaches are low level statistics-based techniques, which are underlying the assumptions of the pixel values or pixel differences (derivatives) distribution in the scene and the gamut-based measures. Gray World (GW), [4] White Patch Retinex (WPR) [5], General Gray World (GGW) [6], Shades of Gray (SoG) [7], first order Gray Edge (GE1), and second order Gray Edge (GE2) all belongs to the first group and the second group contains pixel-based gamut mapping (PBGM)[8], edge-based gamut mapping (EBGM), and intersection-based gamut mapping (IBGM) [9].

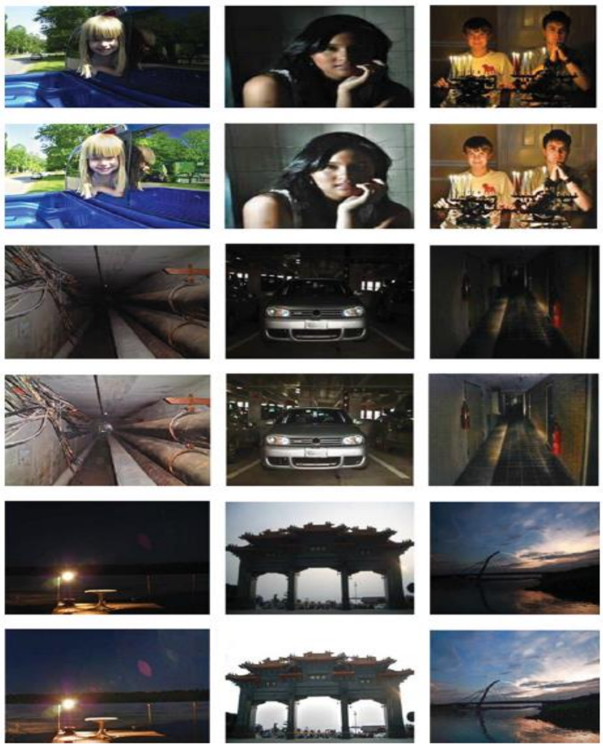

Fig. 7 Odd rows: Natural color images with uneven illumination. Even rows: uneven illumination removal with LBEMD algorithm. Uneven illuminations are removed effectively.

The LBEMD can also be applied to the three color channels (RGB) of color images separately to estimate the reflectances of the three color channels. After we relight these channels using white light and the estimated reflectances, a simple color constancy task can be performed to correct certain poorly lighted color images. In figure 8, we can see from the fur of the tiger that the color cast is greenish. Figure 9 shows the flow chart of our color constancy method. The corrected results of the proposed LBEMD is the best since the white part of the fur indeed looks white and the yellow part is also enhanced. On the other hand, the WPR cannot alleviate the color cast and the outcome still looks greenish.

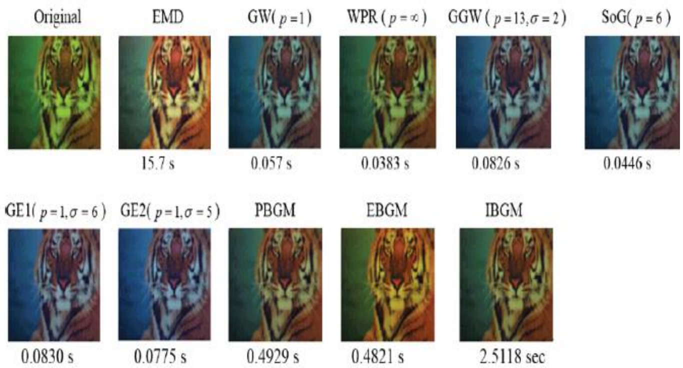

Fig. 8 Comparison of LBEMD color constancy method and other methods. Test image: Tiger.

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Technology

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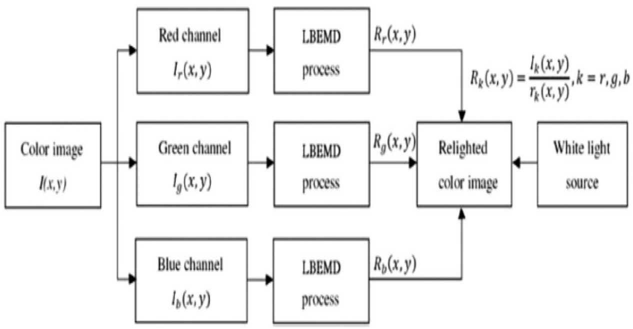

Fig. 9 The processing flow diagram for proposed color constancy method.

For EBGM, the white part of the fur looks greenish even though the yellow part is improved. Finally, the results of GW, GGW, SoG, GE1, and GE2 look somewhat bluish.

In this article, a novel algorithm called LBEMD for uneven illumination removal in images is proposed based on EMD. The LBEMD can be used to correct text image, text-photo images, and natural color/gray-level images. Furthermore, a LBEMD-based color constancy method is proposed to correct poorly-lighted color images, and we obtained satisfactory results. This technique is valuable for improving the quality of images with poorly lighted distribution.

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Development of 3D-IC and Millimeter-Wave Technologies for Next generation computing and Communication Systems

from Electromagnetics Group

Introduction

Recent advance in portable platforms has completely changed the style of data flow in modern society. Owing to the unlimited growth of desires for exploring and sharing high data rate contents, continually increasing in computation power and communication bandwidth is undoubtedly required. Following the Moore's Law for decades, semiconductor industry is gradually approaching the physical limitation of device size. Three dimensional integrated circuit (3D-IC) technology has promised a feasible way at chip scale packaging for increasing the circuit density "More than Moore". On the other hand, frequency bands currently in use for mobile communication suffer from narrow bandwidth and expensive license fee. Millimeter-wave technology, with much lower licensing cost for much higher bandwidth, is believed to be playing an important role in the next generation communication systems. Both aforementioned technologies are paid of high interest in our lab. Research projects have been running for years with some recent results listed below.

Simulation, Characterization, and Compensation for TSVs in 3D-IC

In 3D-IC technologies, chips with different functionalities are stacked on top of each other with an integrated manner on a package as illustrated in Fig. 1. The through silicon vias (TSVs) offer vertical interconnects between different layers of chips and can be thought of as metal vias surrounded by an oxide liner. Comparing to the conventional bonding-wire or flip-chip technology, the TSV has much shorter conduction path and is not necessarily fabricated around the periphery of chip, thereby achieving better electrical performance, higher input/output density, and smaller chip area. However, the TSV might suffer from severe lossy effects of silicon substrate as the operating frequency climbs up to gigahertz (GHz) region at which the oxide liner surrounding the TSV loses its insulated capability such that the transmission feature of the TSV dropped sharply [1].

Practical 3D-IC application may usually involving hundreds or thousands of TSVs. In order to extract their effects accurately and efficiently, our lab proposes a new frequency independent

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conduction model basis function (CMBF) [2] for partial element equivalent circuit method, as shown in Figs. 2(a) and (b). As compared with commercial software package Q3D, only very few segments and harmonics are necessary for the proposed method to obtain results with the same accuracy in the same order of computation time while using several orders less memory.

The characterization of stacked TSVs is difficult because of expensive experiments and low feasibility. In addition, the calibration of transmission lines connecting TSVs and coupling among TSVs is the main obstacle when horizontally connected TSVs are measured, as shown in Fig. 3(a). Therefore, the equivalent transmission matrix of the coupling effect between two adjacent TSVs is derived, and a set of test structures is proposed to extract characteristics of a signal TSV. As shown in Fig. 3(b), under weak coupling conditions, the effect caused by transmission lines and coupling among signals can be eliminated by a calibration mechanism [3]. Hence, extraction results can be used to predict the electrical behavior of stacked TSVs and experiments are inexpensive and feasible.

To compensate the lossy effects of TSV, a novel passive equalizer composed of a parallel resistance–capacitance (RC) circuit is proposed [1]. The conventional transmission line theory is utilized to derive an analytic circuit model of the TSV. Then, the significance analysis is performed to acquire a much simplified capacitance–conductance circuit model which is employed to construct the design formula for the RC equalizer with perfect compensation, as shown in Fig. 4(a). A ten-stacked TSV in series with the designed equalizer is taken as an example, and in the eye diagram, namely, nearly zero timing jitter and three times enlarged eye opening, as shown in Fig. 4(b).

LTCC Laminated Waveguide Components for Millimeter-Wave SiP Application

Millimeter-wave passive components are traditionally built with metallic waveguide technology, which has a high quality factor, but usually at the price of large size, heavy weight, high cost, and not directly compatible with planar systems. Recently, with the advance of the packaging technologies, emerged with much attention is the concept of the laminated waveguide which is embedded in a dielectric substrate with metal layers as the outer surfaces and via arrays as vertical side walls. It can be synthesized by using the printed circuit board (PCB) processes or low-temperature co-fired ceramic (LTCC) technologies. This structure preserves the advantages of the traditional waveguide while still be easily integrated with planar circuits. Moreover, the dielectric substrate can bundle both passive and active components into a single module leading to a system-in-a-package (SiP) solution.

Recently, a novel laminated waveguide diplexer structure has developed by our lab taking advantage of the modal orthogonality of multiple cavity modes [4]. The uplink and downlink channels of the diplexer can share a common filter structure, which minimizes the number of the cavities, as shown in Fig. 5(a). The feeding probes and coupling slots are adequately located to achieve the required coupling coefficients and external quality factors at both passbands simultaneously. In this way, the matching network, i.e., T-junction, adopted in the traditional diplexer design can be eliminated, as shown in Fig. 5(b). In addition, by the symmetric but orthogonal field distributions of two operation modes, nearly 30 dB of isolation can be achieved even by sharing the common cavities, as shown in Figs. 5(c) and (d). The cavities are vertically stacked in LTCC technology, which further miniaturizes the circuit size.

Similar idea has been employed to design a highly integrated multifunctional component which is able to replace the antenna array, 180° hybrid coupler, and filter blocks in the millimeter-wave SiP application, as shown in Fig. 6(a). The TE_{102} and TE_{201} cavity modes shown in Fig. 6(b) can provide even- and odd-symmetric field distributions, respectively, for the coupler, which also exhibit built-in filter function introduced by properly designed coupling structures between adjacent cavities, as shown in Fig. 6(c). By using these two orthogonal modes, the in-phase and out-of-phase responses are accomplished due to the induced mode. Therefore, the sum and difference patterns of the two antenna array can be achieved by in-phase and out-of-phase operation, as shown in Fig. 6(d). With the degenerate, but orthogonal cavity modes, a fewer number of resonators are required and the circuit size can be miniaturized.

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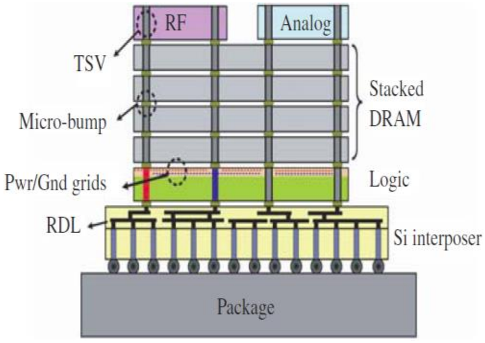


Fig. 1. TSV-based 3-D IC integration.

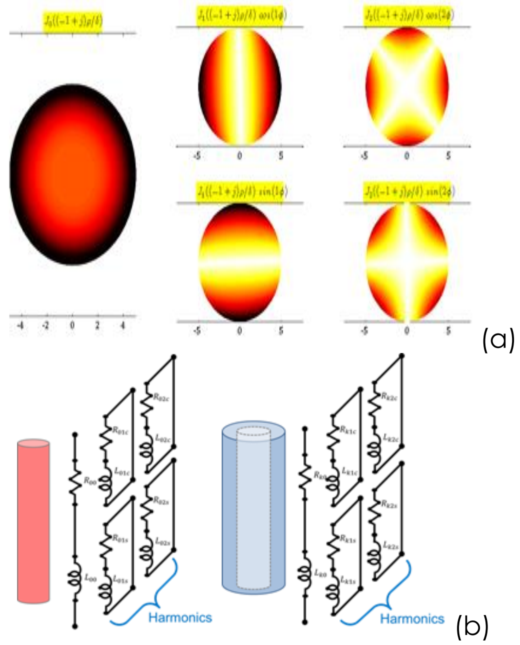


Fig. 2. (a) Conduction model basis function. (b) Piece wise constant elements in radial direction and their equivalent circuit.

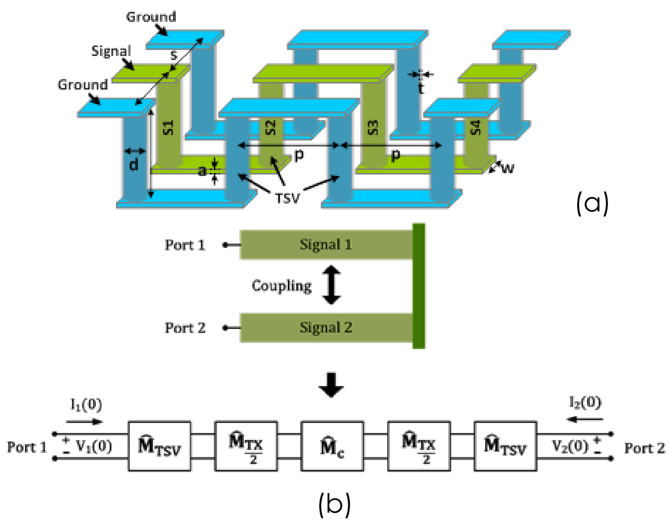


Fig. 3. (a) A TSV test set with daisy chain configuration. (b)

Calibration of mutual coupling between TSVs.

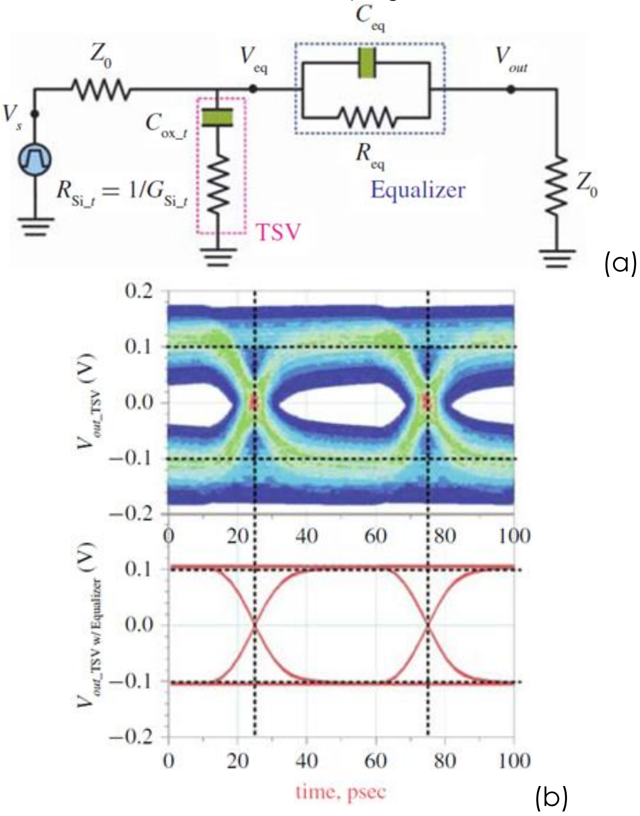
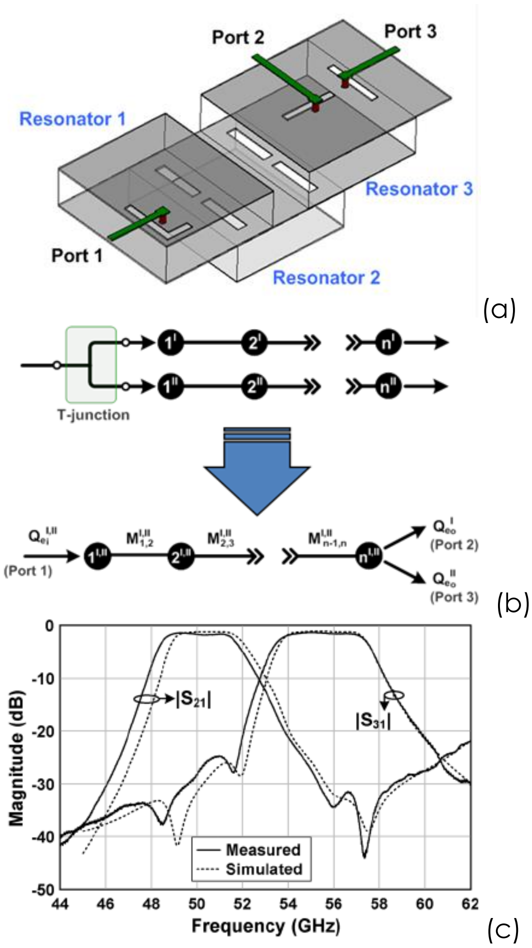


Fig. 4. (a) Simplified TSV model after significant analysis with proposed RC equalizer. (b) Eye diagrams before and after compensation.



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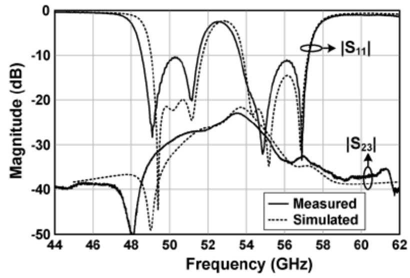

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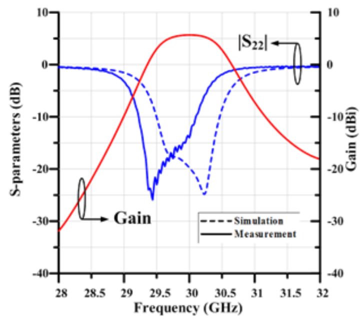
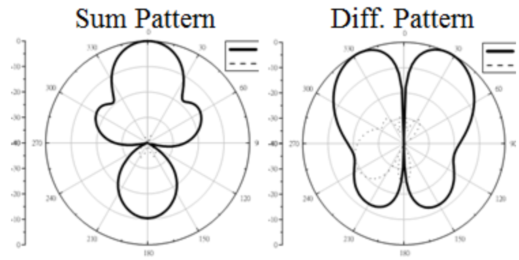


(c)

Fig. 5. (a) LTCC single-branch laminated waveguide diplexer. (b) Traditional and proposed coupling structures. (c) Insertion loss, (d) return loss, and isolation of the diplexer.



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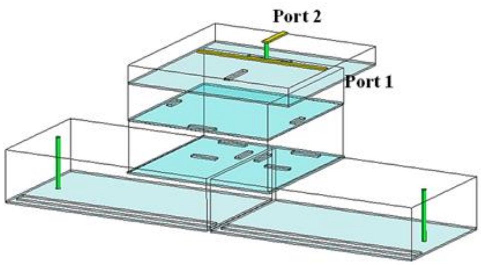
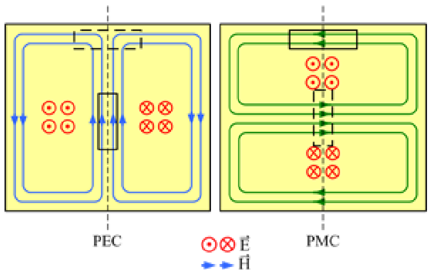


(a)



(b)

Fig. 6. (a) LTCC laminated waveguide filtering antenna array with 180° hybrid coupler function. (b) Exploiting the orthogonal degenerate modes. (c) Frequency response of the gain and return loss in the sum mode operation. (d) Sum and difference pattern.

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Activities

The 2013 4th R&D Workshop on "The Application of the Compound Semiconductors and Silicon-Based SiP/SoP Technology in High-Speed Electronic Devices"

The 2013 4th R&D workshop on the application of compound semiconductor and Silicon-Based SiP/SoP technology in high-speed electronic devices was organized and hosted by Prof. Hwann-Kaeo Chiou (Department of Electrical Engineering, National Central University), sponsored by Taiwan Electromagnetic Industry-Academia Consortium (TEMIAC), and cosponsored by Smart Network System Institute, Information and Communications Research Laboratories of ITRI, IEEE EMC Taipei, Graduate Institute of Communication Engineering of NTU. The Workshop was held at Barry Lam Hall of College of EECS, National Taiwan University in Taipei, Taiwan, R.O.C., on Friday, Dec. 20th, 2013. More than 140 participants from the industrious sector, governmental organizations, academic and research institutions attended the workshop.

The workshop was composed of five distinguished sessions and an inspiring panel discussion. Each topic of the five sessions is as follows:
1. System-in-Package Technology for Next-Generation Wireless Power Amplifiers

2. Low-Cost Broadband Bondwire Interconnection
3. An Introduction of Next-Generation Cloud Server
4. The Current Situation and Trend of GaAs Technology
5. Hybrid IC Packaging Technology

The outstanding speakers from industrious and academic fields, including Prof. J.-H. Chen (Department of Engineering Science and Ocean Engineering, NTU), Prof. Chien-Nan Kuo (Department of Electronics Engineering, NCTU), Dr. Ming-Lin Li (Electronics and Optoelectronics Research Laboratories of ITRI), Dr. Zhen-Kuo Lin

Activities

(Win Semiconductor), Dr. Chen-Zhao Wang (ASE GROUP), not only addressed the current technical issues, but also brought up the challenges and opportunities over the upcoming years on device and Sip/Sop technologies. After five lecture sessions, a panel discussion is provided for the invited experts and audiences to share their opinions mutually.

With the aims of promoting the domestic device and SiP/SoP technologies, the workshop also provided a good chance for students to broaden their vision on the hetero-integration between advance device and packaging techniques and increase the students' professional knowledge.

Corner of Student News

by Yun-Da Huang

I'd like to thank the Graduate Students Study Abroad (GSSA) program sponsored by the National Science Council, who has given me the chance to observe and learn from the real life in the States. It has been a great honor for me to be a visiting scholar in the University of Minnesota. I wandered about unhurriedly within the campus during my first day; I reveled among these Baroque buildings. The Walter Hall with a coffee shop in the Minneapolis campus is a gallant and a romantic library, where I can order a delicious cup of coffee and spend my whole day to do research. That is an unbelievable scene in Taiwan.

Shortly after I settled down, I visited Chicago and Yellowstone national park. In Chicago, the old elevated transit and the middle aged buildings attracted me to plumb into the history of this city. Besides, the modern skyscrapers and the millennium park created conflicting and inconsistent beauty, which constitutes to the incredible night sceneries. And last but not the least, the museums in Chicago are just amazing. The dinosaurian fossil, the U-boat in World War II and the American spacecraft Apollo 8 are sincerely authentic. As for the trip to the Yellowstone national park, I almost screamed out when I saw the bison, elk and grizzly. These wild animals crossed the road and even directed the traffic. If these adorable animals can't touch you, there are also some fantastic geysers and spectacular canyons that must be able to bring content to your curiosity about Nature.

In the US, some big cities are referred to as a "melting pot" because of the diversity of cultures living here. But, how could they merge together? In my experience, the most important and admirable custom in this country is the warm greeting I always hear i.e. "Have a nice day!" Every time I meet with my friends or any strangers, they always start a conversation with "Is everything OK?" and end in "Have a nice day!" Such friendly and warm greetings not only close the gap between me and the others but it also lighten up my spirit all day long. After understanding the culture here and even accepting them open-mindedly, I made a lot of new friends. The culture here is so much different compared to ours in Taiwan, that's a bit more conservative. This has been a wonderful and a memorable journey for me. If you want to live the real life in the US, how about let's keep saying "Is everything OK?" at first, and then I believe you'd definitely "have a nice day!"

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