High-performance InP/InGaAs heterojunction bipolar phototransistors for optoelectronic applications

Jihane Ouchrif, Abdennaceur Bagkhdad, Aïcha Sahel, Abdelmajid Badri
Laboratory of Electronics, Energy, Automation and Information Processing (LEEA&TI), Department of Electrical Engineering, Faculty of Sciences and Techniques, Hassan II University of Casablanca, Mohammedia, Morocco

ABSTRACT

Phototransistors are attractive devices for applications in optical fiber telecommunication systems. They are used for the detection of optical signals and the amplification of these signals. This paper presents an investigation of how the technological parameters of indium phosphide (InP)/indium gallium arsenide (InGaAs) heterojunction bipolar phototransistor can impact its responsivity at two wavelengths, 1310 nm and 1550 nm. Based on the results of this investigation, we proposed optimized structures for the studied phototransistor. In this work, we used the software technology computer aided-design (TCAD)-Silvaco to simulate the physical and the electrical behavior of the different structures. The proposed optimized phototransistors can be used for various optoelectronic applications.

Keywords: Bipolar phototransistor, InP/InGaAs heterojunction, Optical fiber, Telecommunication systems, Optoelectronic applications, Responsivity, TCAD-Silvaco

This is an open access article under the CC BY-SA license.

Corresponding Author:
Jihane Ouchrif
Laboratory of Electronics, Energy, Automation and Information Processing (LEEA&TI)
Department of Electrical Engineering, Faculty of Sciences and Techniques
Hassan II University of Casablanca
Mohammedia, Morocco
Email: ouchrif.jihanel@gmail.com

1. INTRODUCTION

Semiconductor devices are indispensable for communication and information systems, they are more requests for various applications. III-V semiconductor materials are used in the fabrication of electronic devices owing to their transport properties. They have a direct band gap, and their electronic mobility is high. They have exceptional speed characteristics, furthermore they enable the operation of electronic devices at high frequencies [1].

Indium phosphide (InP) and indium gallium arsenide (InGaAs) are semiconductor materials of the III-V family of semiconductors. InP-InGaAs HBTs have proved to be excellent electronic devices, they are characterized by high electrical performances of speed and superior frequency [2], [3], and excellent current handling capability [4]. The heterojunction bipolar phototransistor (HPT) has almost the same epitaxial layer as the HBT, but the exclusive difference is in the electrode structure which allows illumination at the top of the device structure [5], [6]. The optical signal is absorbed in the base-collector region, and the signal is amplified by the intrinsic gain of the transistor [7], [8].

Different research works on HPT were performed for several decades [9]–[11]. HPTs are considered promising alternatives to devices such as metal-semiconductor-metal (MSM), the PIN and avalanche photodiodes [12], [13]. Furthermore, HPTs are more advantageous for highly sensitive infrared photodetection and imaging over the PIN and the avalanche photodiode (APD) due to their excellent characteristics of high gains without differences in high potentials and without excess noise [14]–[16]. In addition, the operation of HPTs can be done at a low bias voltage, and with a low gain sensitivity to the bias voltages [17]. There are
several applications where photodetectors based on InP are requested and used, such as biomedical field, optical communication systems, environment and also firms of chemistry for near infrared (NIR) light detection [18].

The objective of this work is to investigate the impact of technological parameters on the electrical performances of the InP/InGaAs HPT in terms of the responsivity at the wavelengths 1310 nm and 1550 nm. This investigation will help us to propose some optimized devices with different values of responsivities. These devices can be used in various optoelectronic applications.

2. **INDIUM PHOSPHIDE/INDIUM GALLIUM ARSENIDE HPT MODELLING**

In this work, we designed the InP/InGaAs HPT, which is mainly based on the HBT structure studied in papers [2], [19]–[21]. It is basically composed of two III-V semiconductor materials made from two alloys, a binary alloy for InP, and InGaAs. The topology of HBT structure has been adapted to receive light. Regarding the modifications made in HBT structure, a base contact has been removed, and the emitter contact has been reduced. The type of illumination is from above.

As detailed in Table 1 and shown in Figure 1, the epitaxial layer structure of the InP/InGaAs HPT comprises a cap layer, an emitter 1 layer, an emitter 2 layer, a spacer layer, a base layer, a collector layer, a sub-collector layer and a buffer layer. For the fabrication of this device, there are different techniques used for the growth of epitaxial layers such as metal organic chemical vapor deposition (MOCVD), and molecular jet epitaxy (MBE) technique [22].

Figure 1 shows the device structure of the InP/InGaAs HPT that respects the order of the epitaxial layers of the Table 1. It is an NPN heterojunction bipolar phototransistor; the ohmic contacts are made of the material gold. In the top view, the optical window as illustrated is the space between the base and the emitter. The illuminated surface is equal to 4x4 μm². The illumination is considered vertical to the HPT optical window. To design the device structure, we have carefully layered and meshed the InP/InGaAs HPT using the device editor DevEdit which allows the creation of the device structure.

### Table 1. Layer structure for lattice-matched InP/In_{0.47}Ga_{0.53} HPT

<table>
<thead>
<tr>
<th>Layer</th>
<th>Material</th>
<th>Doping (cm⁻³)</th>
<th>Thickness (nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cap</td>
<td>In_{0.47}Ga_{0.53}As</td>
<td>n=1x10¹⁹</td>
<td>135</td>
</tr>
<tr>
<td>Emitter 1</td>
<td>In_{0.47}Ga_{0.53}As</td>
<td>n=1x10¹⁷</td>
<td>135</td>
</tr>
<tr>
<td>Emitter 2</td>
<td>InP</td>
<td>n=1x10¹⁷</td>
<td>40</td>
</tr>
<tr>
<td>Spacer</td>
<td>In_{0.47}Ga_{0.53}As</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>Base</td>
<td>In_{0.47}Ga_{0.53}As</td>
<td>p=1.5x10¹⁹</td>
<td>65</td>
</tr>
<tr>
<td>Collector</td>
<td>In_{0.47}Ga_{0.53}As</td>
<td>n=1x10¹⁶</td>
<td>630</td>
</tr>
<tr>
<td>Sub-collector</td>
<td>In_{0.47}Ga_{0.53}As</td>
<td>n=1x10¹⁹</td>
<td>500</td>
</tr>
<tr>
<td>Buffer</td>
<td>In_{0.47}Ga_{0.53}As</td>
<td>-</td>
<td>10</td>
</tr>
<tr>
<td>Substrate</td>
<td>Semi-insulating InP</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

![Figure 1. Schematic device structure of the InP/In_{0.47}Ga_{0.53} HPT](image)

2.1. **Physical and numerical modelling of InP/InGaAs HPT**

ATLAS is a device simulator. It helps users predict the electrical behavior of any electronic device. It has been integrated into the simulation program for the physical and numerical modelling of HPT.

**High-performance InP/InGaAs heterojunction bipolar phototransistors ... (Jihane Ouchrif)**
2.1.1. Physical modelling

The physical modelling of electronic devices allows to take into consideration the physical phenomena and mechanisms occurring within these devices. After designing the HPT device structure, we added in the simulation some physical models integrated into the simulator. Among these physical models, we cite the carrier statistical model (BGN), the recombination model (SRH), the Selberherr’s model of the impact of ionization (IMPACT SELB), the band-to-band model (BBT.STD), the optical recombination model (OPTR), the parallel electric field dependence model (FLDMOB), and the Fermi-dirac model (FERMI).

2.1.2. Numerical modelling

Semiconductor equations were solved employing the newton method. Among these equations, the carrier continuity equations, the Poisson’s equation, the drift and the diffusion equations for both the electrons and the holes. These equations allow calculating currents, potentials and charge carriers, more details can be found elsewhere [21].

3. RESULTS AND DISCUSSION

This study is carried out at room temperature T=300 K, for the two wavelengths 1310 nm and 1550 nm. The photodiode mode is taken for at $V_{ce}=0$ V and $V_{be}=0$ V. The phototransistor mode is considered for the bias conditions at $V_{ce}=1.6$ V and $V_{be}=0.86$ V.

3.1. HPT responsivity

3.1.1. Responsivity definition

The responsivity $R(\lambda)$ is defined as the ratio of photo-generated current to the input optical power and is expressed as (1) [5], [23]:

$$R(\lambda) = \frac{\lambda I_{C}(\lambda)}{hc\Phi_{0}(1-R_{f})}$$

where $h$ is planks constant, $c$ is the velocity of light, $\Phi_{0}$ is total incident flux density and $R_{f}$ is the Fresnel reflection coefficient. The flux-dependent collector current ($I_{C}$) is the sum of individual current contributions in the base, sub-collector and B-C depletion regions [23].

The phototransistor is working in two modes, photodiode mode and phototransistor mode; we are more interested in the phototransistor mode. The figures below present the simulation results of the studied InP/InGaAs HPT. We simulated the collector current as a function of light intensity, after that we extracted the responsivity in phototransistor mode $R_{HPT}$. For the applied light intensity, it is from 0 to 100 W/cm². All the results for responsivity are taken for the phototransistor mode, more precisely for $V_{ce}=1.6$ V and $V_{be}=0.86$ V. We investigated the impact of technological parameters on the responsivity of the studied HPT.

3.1.2. Responsivity of the studied HPT at $\lambda=1310$ nm and $\lambda=1550$ nm

Figure 2 and Figure 3 present the evolution of the collector current (A) as a function of the light intensity (W/cm²) respectively at $\lambda=1310$ nm and $\lambda=1550$ nm. The light intensity is from 0 to 100 W/cm². It is clearly noticed a linear evolution, the collector current increases gradually with the increase of the applied light intensity. The responsivity $R_{HPT}$ is approximately equal to 3.2 A/W at $\lambda=1310$ nm, and it is around 2.7 A/W at $\lambda=1550$ nm.

![Figure 2. Collector current as a function of light intensity at $\lambda=1310$ nm and $V_{ce}=1.6$ V](image1)

![Figure 3. Collector current as a function of light intensity at $\lambda=1550$ nm and $V_{ce}=1.6$ V](image2)
We have investigated the impact of technological parameters of the studied phototransistor on its responsivity in the phototransistor mode. This investigation was performed at room temperature T=300 K respectively for the wavelength $\lambda=1310$ nm and $\lambda=1550$ nm. The evaluated technological parameters are the base width, the base doping, and the collector doping.

A. Impact of technological parameters on responsivity in phototransistor mode at $\lambda=1310$ nm

1) Impact of base width

Based on Figure 4, the collector current (A) increases with the application of light intensity (W/cm$^2$). We noticed that the collector current increases with the reduction of the base width $W_b$. Figure 5 shows the responsivity $R_{HPT}$ (A/W) of the HPT that varies according to the base width $W_b$ for the wavelength $\lambda=1310$ nm. We observed that the responsivity had an increasing trend with the decrease in the base width. Therefore, the decreased values of base width allowed obtaining high values of the responsivity of the HPT, the intrinsic current gain of a transistor increases when we reduce the base width [20]. The base width has the same important impact for the intrinsic current gain and the responsivity.

2) Impact of base doping

Figure 6 presents the evolution of the collector current (A) as a function of the light intensity (W/cm$^2$) for different base doping $N_b$ at $\lambda=1310$ nm. According to Figure 7, we find that when the base doping $N_b$ is reduced, the responsivity $R_{HPT}$ (A/W) increases gradually and reaches a large value for $N_b = 1 \times 10^{18} cm^{-3}$. The base doping $N_b$ has a significant impact on the responsivity of the studied phototransistor.
3) Impact of collector doping

According to Figure 8, the collector current $I_C$ increases with the increasing of applied light intensity (W/cm$^2$) at $\lambda=1310$ nm. The investigated values of collector doping are between $1\times10^{14}$ cm$^{-3}$ and $1\times10^{17}$ cm$^{-3}$. Based on Figure 9, we noticed from the examined values that the responsivity $R_{HPT}$ (A/W) increases slowly and its value is constant for some values of $N_C$. Collector doping has a small impact on HPT responsivity compared to other technological parameters.

![Figure 8](image1.png)

![Figure 9](image2.png)

Figure 8. Collector current as a function of light intensity for different collector doping $N_C$ at $\lambda=1310$ nm and $V_{ce}=1.6$ V

Figure 9. Responsivity as a function of collector doping $N_C$ at $\lambda=1310$ nm and $V_{ce}=1.6$ V

B. Impact of technological parameters on responsivity in phototransistor mode at $\lambda=1550$ nm

1) Impact of base width

Figure 10 presents the curve of collector current $I_C$ as a function of the light intensity for different values of base width $W_b$ between 45 nm and 85 nm. According to Figure 11, it is observed that the responsivity $R_{HPT}$ (A/W) decreases with the increasing of the base width $W_b$ at the wavelength 1550 nm. The base width as a technological parameter has an impact on the responsivity of this studied photodetector.

![Figure 10](image3.png)

![Figure 11](image4.png)

Figure 10. Collector current as a function of light intensity for different base width $W_b$ at $\lambda=1550$ nm and $V_{ce}=1.6$ V

Figure 11. Responsivity as a function of base width $W_b$ at $\lambda=1550$ nm and $V_{ce}=1.6$ V

2) Impact of base doping

Figure 12 presents the evolution of the collector current as a function of the light intensity (W/cm$^2$) for different base dopings $N_b$ at $\lambda=1550$ nm. Based on Figure 13, we find that the responsivity $R_{HPT}$ (A/W) increases when the base doping $N_b$ is reduced. The base doping $N_b$ corresponding to $1\times10^{18}$ cm$^{-3}$ gives the highest responsivity among the investigated base dopings ranging from $1\times10^{18}$ cm$^{-3}$ up to $1\times10^{20}$ cm$^{-3}$. Therefore, the base doping $N_b$ has a considerable impact on the responsivity of the phototransistor.
High-performance InP/InGaAs heterojunction bipolar phototransistors (Jihane Ouchrif)

3) Impact of collector doping

According to Figure 14, the collector current $I_C$ increases with the increasing of the applied light intensity (W/cm²) at $\lambda=1550$ nm. The investigated values of collector doping range from $1 \times 10^{14}$ cm⁻³ to $1 \times 10^{17}$ cm⁻³. Based on Figure 15, we noticed that responsivity $R_{HPT}$ as a function of collector doping $N_c$ varies in a very light way. The responsivity increases slightly.

### Table 2. Proposed optimized topologies HPTs

<table>
<thead>
<tr>
<th>Changed parameters</th>
<th>Studied structure</th>
<th>Optimized structure A</th>
<th>Optimized structure B</th>
<th>Optimized structure C</th>
<th>Optimized structure D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base width $W_b$(nm)</td>
<td>65</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Base doping $N_b$(cm⁻³)</td>
<td>1.5x10¹⁹</td>
<td>1x10¹⁹</td>
<td>5x10¹⁸</td>
<td>2x10¹⁸</td>
<td>1x10¹⁸</td>
</tr>
<tr>
<td>Collector doping $N_c$(cm⁻³)</td>
<td>1x10¹⁶</td>
<td>1x10¹⁷</td>
<td>1x10¹⁷</td>
<td>1x10¹⁷</td>
<td>1x10¹⁷</td>
</tr>
</tbody>
</table>

A. Responsivity of the optimized structure A

Figures 16 and 17 present the evolution of the collector current $I_C$ as a function of the light intensity in phototransistor mode at $V_{ce}=1.6$ V respectively for $\lambda=1310$ nm and $\lambda=1550$ nm. The collector current $I_C$ increases with the increasing of the applied light intensity (W/cm²) which range between 0 to 100 W/cm². The responsivity $R_{HPT}$(A/W) of the optimized structure A is around 7 A/W for $\lambda=1310$ nm, and it is around 3.8 A/W for $\lambda=1550$ nm.

Figure 12. Collector current as a function of light intensity for different base doping $N_b$ at $\lambda=1550$ nm and $V_{ce}=1.6$ V

Figure 13. Responsivity as a function of base doping $N_b$ at $\lambda=1550$ nm and $V_{ce}=1.6$ V

Figure 14. Collector current as a function of light intensity for different collector doping $N_c$ at $\lambda=1550$ nm and $V_{ce}=1.6$ V

Figure 15. Responsivity as a function of collector doping $N_c$ at $\lambda=1550$ nm and $V_{ce}=1.6$ V
B. Responsivity of the optimized structure B

As shown in Figures 18 and 19, the collector current $I_C$ varies as a function of the light intensity in phototransistor mode at $V_{ce}=1.6$ V respectively for $\lambda=1310$ nm and $\lambda=1550$ nm. We applied light intensity (W/cm$^2$) ranging from 0 to 100 W/cm$^2$. We noticed that the collector current $I_C$ is increasing with the increase of the light intensity (W/cm$^2$). The responsivity $R_{HP}(A/W)$ of the optimized structure B is around 13.1 A/W for $\lambda=1310$ nm, and it is around 10.9 A/W for $\lambda=1550$ nm.

C. Responsivity of the optimized structure C

From Figures 20 and 21, the collector current varies according to the light intensity in phototransistor mode at $V_{ce}=1.6$ V respectively for $\lambda=1310$ nm and $\lambda=1550$ nm. The collector current increases gradually with increasing application of light intensities ranging from 0 to 100 W/cm$^2$. The responsivity $R_{HP}(A/W)$ of the optimized structure C is around 29.3 A/W for $\lambda=1310$ nm, and it is around 24.3 A/W for $\lambda=1550$ nm.

Figure 16. Collector current as a function of light intensity at $\lambda=1310$ nm and $V_{ce}=1.6$ V

Figure 17. Collector current as a function of light intensity at $\lambda=1550$ nm and $V_{ce}=1.6$ V

Figure 18. Collector current as a function of light intensity at $\lambda=1310$ nm and $V_{ce}=1.6$ V

Figure 19. Collector current as a function of light intensity at $\lambda=1550$ nm and $V_{ce}=1.6$ V

Figure 20. Collector current as a function of light intensity at $\lambda=1310$ nm and $V_{ce}=1.6$ V

Figure 21. Collector current as a function of light intensity at $\lambda=1550$ nm and $V_{ce}=1.6$ V
D. Responsivity of the optimized structure D

According to Figures 22 and 23, the collector current evolves in a linear way with the application of the light intensity in phototransistor mode at $V_{ce}=1.6$ V respectively for $\lambda=1310$ nm and $\lambda=1550$ nm. The light intensity varies from 0 to 100 W/cm$^2$. The responsivity $R_{HPT} (\text{A/W})$ of the optimized structure D is equal to 57.8 A/W for $\lambda=1310$ nm, and it is of the order of 48.1 A/W for $\lambda=1550$ nm.

![Figure 22. Collector current as a function of light intensity at $\lambda=1310$ nm and $V_{ce}=1.6$ V](image)

![Figure 23. Collector current as a function of light intensity at $\lambda=1550$ nm and $V_{ce}=1.6$ V](image)

3.1.4. Comparison with other research works

Table 3 presents the comparison between our results and some other research works, we were able to design photodetector topologies based on HPT InP/InGaAs. We obtained promising results in terms of responsivity which is a performance parameter allowing the characterization of photodetectors. These optimized structures can be used for digital fiber and microwave telecommunications applications.

<table>
<thead>
<tr>
<th>Reference</th>
<th>$R_{HPT} (\lambda=1310 , \mu m)$</th>
<th>$R_{HPT} (\lambda=1550 , \mu m)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jeong et al. [24]</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>Our work before optimization</td>
<td>3.2</td>
<td>2.7</td>
</tr>
<tr>
<td>Optimized structure A</td>
<td>7</td>
<td>3.8</td>
</tr>
<tr>
<td>Optimized structure B</td>
<td>13.1</td>
<td>10.9</td>
</tr>
<tr>
<td>Optimized structure C</td>
<td>29.3</td>
<td>24.3</td>
</tr>
<tr>
<td>Optimized structure D</td>
<td>57.8</td>
<td>48.1</td>
</tr>
<tr>
<td>Ouchrif et al. [25]</td>
<td>10</td>
<td>8.4</td>
</tr>
<tr>
<td>Khan et al. [5]</td>
<td>11</td>
<td>8.7</td>
</tr>
<tr>
<td>HPT without optical waveguide [26]</td>
<td>-</td>
<td>4</td>
</tr>
<tr>
<td>HPT with integrated optical waveguide [26]</td>
<td>-</td>
<td>29</td>
</tr>
</tbody>
</table>

4. CONCLUSION

In this present work, we investigated the impact of technological parameters on responsivity of InP/InGaAs HPT. Our results are mainly based on this investigation, and our objective is to design optimized structures using technology computer aided-design (TCAD)-Silvaco at the two wavelengths $\lambda=1310$ nm and $\lambda=1550$ nm. We proposed four structures. The optimized structure A has a responsivity of 7 A/W for $\lambda=1310$ nm and 3.8 A/W for $\lambda=1550$ nm. The optimized structure B has a responsivity of 13.1 A/W for $\lambda=1310$ nm and 10.9 A/W for $\lambda=1550$ nm. The optimized structure C has a responsivity of 29.3 A/W for $\lambda=1310$ nm and 24.3 A/W for $\lambda=1550$ nm. The optimized structure D has a responsivity of 57.8 A/W for $\lambda=1310$ nm and 48.1 A/W for $\lambda=1550$ nm. The proposed phototransistors were compared with other research works. These optimized structures can be integrated as photodetectors in different optoelectronic applications.

ACKNOWLEDGEMENTS

We gratefully thank L’Oréal and UNESCO for the financial support and encouragement of our scientific research. Thanks to the award the “2020 L’Oréal-UNESCO Young Talents Maghreb For Women in Science”, this work is published.

*High-performance InP/InGaAs heterojunction bipolar phototransistors ... (Jihane Ouchrif)*
REFERENCES


**BIOGRAPHIES OF AUTHORS**

**Jihane Ouchrif** holds a Ph.D. degree in Electrical Engineering and Telecommunications in 2020 from the Faculty of Sciences and Techniques of Mohammadia, Hassan II University of Casablanca. She obtained an engineering degree in 2012 in Mechatronics from The National School of Applied Sciences of Tetouan. Her research areas are optoelectronics, semiconductor physics and devices. She worked as a technical engineer in Moroccan companies. She did scientific research in the EEA and TI Laboratory where she works on the design, the modeling and the simulation of different transistors in order to improve their electrical performances for applications in fiber-optic telecommunication systems, and she was under the supervision of Pr. A. Baghdad. She worked as a lecturer in the Faculty of Sciences and Techniques of Mohammadia. She can be contacted at email: ochrif.jihane1@gmail.com.

**Abdennaceur Baghdad** is a holder of a Ph.D. in Electronics in 1992 at the University of Lille in France. He is a University Professor at Faculty of Sciences and Techniques of Mohammadia, Hassan II University of Casablanca, Morocco. He teaches the electronics, Hyper frequencies, antenna and telecommunications. He is a member of the laboratory EEA and TI (Electronics, Energy, Automatic and Information Processing). The research works of A. Baghdad concerns the communication and information technology (electronic systems and telecommunication). He supervises doctoral theses and he is a co-author of several national and international publications. He was a member of steering committees of several international congresses in the same field of research. He can be contacted at email: nasser_baghdad@yahoo.fr.

**Aicha Sahel** is a holder of a Ph.D. in Electronics and Image Processing in 1996 at the University of Poitiers in France. She works as a University Professor at the Faculty of Sciences and Techniques of Mohammadia, Hassan II University of Casablanca, Morocco. She teaches electronics, the signal processing, the image processing and Telecommunication. She is a member of the laboratory EEA and TI (Electronics, Energy, Automatic and Information Processing). The research works of A. Sahel concern the communication and information technology (electronic systems, signal/image processing and telecommunication). She co-supervises doctoral theses and she is a co-author of several national and international publications. She was a member in financed research projects. She was a member of steering committees of several international congresses in the same field of research. She can be contacted at email: sahel_ai@yahoo.fr.

**Abdelmajid Badri** is a holder of a Ph.D. in Electronics and Image Processing in 1992 at the University of Poitiers in France. In 1996, he obtained the diploma of the authorization to manage Researches in the University of Poitiers in France on the image processing. He is a University Professor in the Faculty of Sciences and Techniques of Mohammadia, Hassan II University of Casablanca, Morocco. He teaches the electronics, the signal processing, the image processing and telecommunication. He is a member of the laboratory EEA and TI (Electronics, Energy, Automatic and Information Processing) which he managed since 1996. The research works of A. Badri concerns the communication and the information technology (electronic systems, signal/image processing and telecommunication). He is qualified by CNU-France in 61th section: informatics engineering, automatic and signal processing. He managed several doctoral theses. He is a co-author of several national and international publications. He is responsible for several research projects financed by the ministry or by the industrials. He was member of different committees of programs of international conferences and president of several international congresses in the same research field. He is a member and co-responsible in several scientific associations of the same research field. He can be contacted at email: abdelmajid_badri@yahoo.fr.